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CEREAL INVESTIGATIONS AT THE NEPHI SUBSTATION.[1]

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(In cooperation with the Utah Agricultural Experiment Station.)

INTRODUCTION.

The cooperative experiments conducted at the Nephi (Utah) substation since 1907 comprise two distinct but closely related groups: (1) Varietal and improvement tests of several dry-land crops, and (2) cultural experiments with these crops. The experiments are confined to dry-land crops and practices. They deal chiefly with the cereals, of which wheat is the most important. Winter varieties of wheat, oats, and barley are much more important than spring varieties.

Only those investigations which concern the first group of experiments, i. e., varietal and improvement tests, are dealt with in this bulletin.

A preliminary report of cooperative cereal investigations at the Nephi substation was published in the spring of 1910.[2] This report covered the work from the beginning of the cooperation [3] on July 1, 1907, to the end of the season of 1909. Most of the experiments

[1] The Nephi substation was established in 1903 by the Utah Agricultural Experiment Station. From that time until July 1, 1907, it was operated as one of several "county farms" located at various points in the State. Prof. L. A. Merrill, agronomist of the Utah station, directed the work from 1903 to 1905. Thereafter until 1907 it was under the direction of Prof. W. M. Jardine, agronomist of the Utah station. On July 1, 1907, cooperation between the Utah experiment station and the Bureau of Plant Industry was effected, and F. D. Farrell, of the U. S. Department of Agriculture, was placed in charge of the substation. He was succeeded on March 15, 1910, by the present superintendent. From the time of the establishment of the station until July 1, 1912, at which time he was succeeded by Mr. A. D. Ellison, Mr. Stephen Boswell was foreman. From 1907 to 1912 the State of Utah has been represented through Prof. L. A. Merrill, agronomist in charge of arid farms.

[2] Farrell, F. D. Dry-land grains in the Great Basin. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 61, 40 p., 1910.

[3] On July 1, 1907, a "memorandum of understanding between the Utah Agricultural Experiment Station and the Bureau of Plant Industry, U. S. Department of Agriculture," was accepted by both parties. This memorandum specified that "the objects of these cooperative investigations shall be (1) to improve the cereals of the intermountain region by introducing or producing better varieties than those now grown, especially with regard to drought resistance, yield, quality, earliness, etc.; (2) to conduct such other experiments as might seem advisable for the accomplishment of the greatest possible good to the dry-land interests of the State."

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reported in this bulletin were begun during that period, but the work had not progressed far enough in 1909 to warrant the publication of any conclusions. Now, however, considerable definite information is at hand, which is presented and discussed herein.

DESCRIPTION OF THE SUBSTATION.

It is believed that the results obtained at Nephi are applicable to only a portion of the Great Basin area. In many sections of the Great Basin the rainfall is so limited that dry farming as it is now understood is quite impossible. There are many thousands of acres

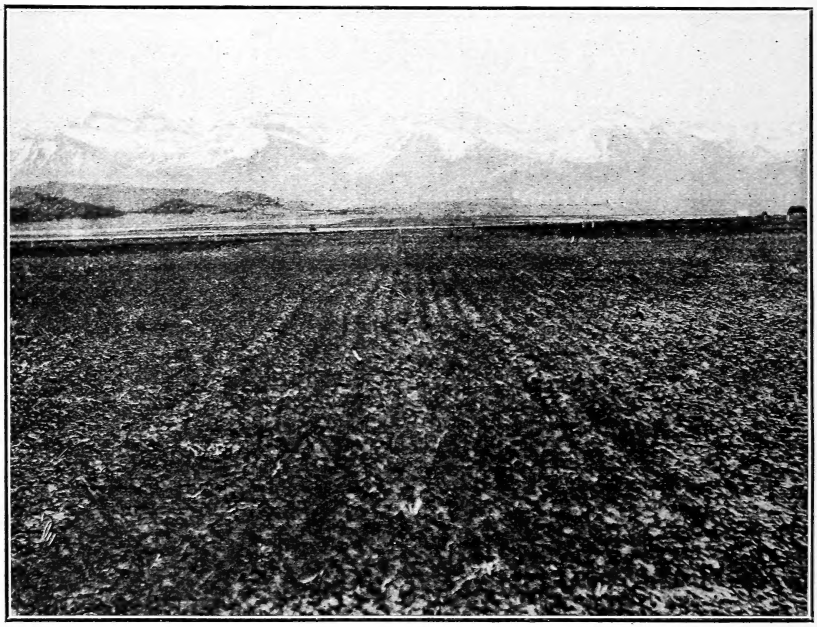

FIG. 1.—View of a portion of the Juab Valley, Utah, looking east along the Levan Ridge toward the Wasatch Range. The substation farm occupies the foreground. Photographed April 23, 1912.

in this area, however, where the results obtained at the Nephi substation are applicable. A comparison of the climate of any section with that of Nephi will show whether or not it is safe to apply them. In making such a comparison the exact location, the amount and distribution of the rainfall, and other climatological factors should be considered in detail before any conclusions are drawn. In order to allow such a comparison, a detailed description of the Nephi substation is here given.

LOCATION.

The Nephi substation is located in Juab Valley, in the eastern part of Juab County, Utah, almost in the center of the State. This valley

is fairly typical, in its orientation and proportions, of most of the valleys in the intermountain region. It is about 20 miles long from north to south and from 3 to 5 miles wide. South of the city of Nephi a transverse ridge, called the Levan Ridge, crosses the valley from east to west. This ridge, which is rather fan shaped, slopes gradually in three directions from the east, where it abuts upon the base of the mountains. It is from 5 to 6 miles wide, and the crest is about 500 feet above the valley floor, or nearly 6,000 feet above sea level. Dry farming is practiced generally over the ridge. Under the system of alternate fallowing and cropping which is followed, from 150,000 to 175,000 bushels of winter wheat are produced annually.

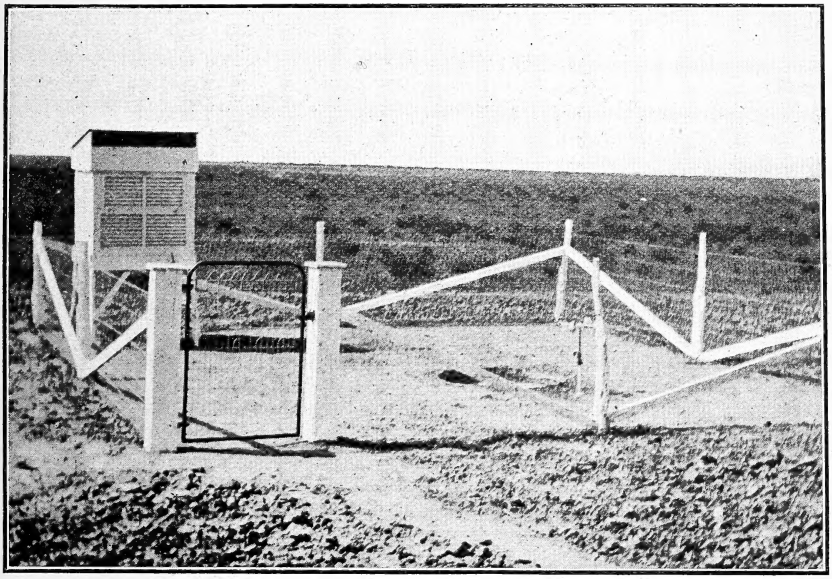

FIG. 2.—Instruments for recording physical data at the substation, Nephi, Utah.

The substation is about 6 miles south of the city of Nephi. It comprises about 100 acres of land, situated near the top of the north slope of the Levan Ridge. Figure 1 shows a view of the Juab Valley in the vicinity of the substation.

PHYSICAL FACTORS.

In making a study of crop yields for a series of years it is essential first to have some knowledge of the physical factors which have influenced the growth of the crops. The most important physical factors to be considered are: (1) The soil; (2) rainfall, its distribution and amount during each month and during the year; (3) evaporation, especially that during the crop season; (4) wind, with special reference to that which passes directly over the ground sur-

face; and (5) temperature, especially the frequency of killing frosts which limit the growing period. These factors will be discussed as they have been recorded[1] at the Nephi substation. Figure 2 shows the apparatus used in recording these data.

FIG. 3.—View of one wall of a deep gully or small canyon near the Nephi substation, showing stratified soil formation to a depth of 20 feet. The light-colored stratum is the blue clay mentioned in the text.

SOIL.

The soil of the Nephi substation is reasonably typical of a large proportion of the soils of the Great Basin, which are mostly alluvial.

[1] With the exception of the rain gauge, the physical apparatus in use at the substation was installed by the Biophysical Laboratory of the Bureau of Plant Industry, which is cooperating in the work. The apparatus includes an evaporation tank, an anemometer, an air thermograph, thermometers, psychrometers, and a complete outfit for making soil-moisture determinations.

That at Nephi is very deep and is mostly reddish brown in color. The upper 3 or 4 feet of soil are composed of clay loam, containing about 15 per cent of clay. This relatively high percentage of clay makes the soil rather difficult to handle in either wet or extremely dry weather. The second and third feet of soil contain a noticeable but scattered amount of gypsum which has been washed from the extensive deposits found on the mountains to the east. The fifth, sixth, and seventh feet contain a larger percentage of fine sand and silt, with occasional pockets of gravel. From the eighth to the tenth foot there is a stratum of rather heavy blue clay, which usually has a comparatively high moisture content. The root system of a winter-wheat plant which was washed out in 1910 was found to terminate

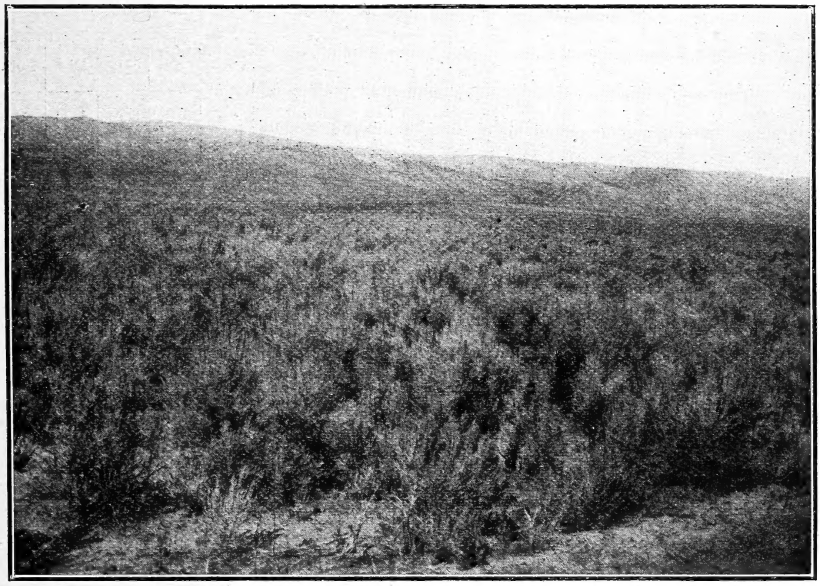

FIG. 4.—View of a portion of the Juab Valley near the Nephi substation, showing characteristic vegetation, mostly sagebrush.

in this blue stratum. That this would be the case generally can be only assumed. Below the blue stratum the soil alternates between a clay and a sandy loam to great depths. Figure 3 shows the different strata of soil as they appear in a deep gulch near the station farm.

NATIVE VEGETATION.

According to old settlers of that section, the Levan Ridge was covered with "bluegrass" (*Agropyron* sp.) as late as 50 years ago. At that time the grass was sometimes cut for hay. Later, sheep grazed the ridge heavily and plants not good for forage soon began

to take the place of the "bluegrass." In 1903, when the substation was established, the entire ridge was covered with sagebrush (*Artemisia tridentata*). (Fig. 4.)

RAINFALL.

Table I contains a record of the annual precipitation in the Juab Valley by months for the years 1898 to 1912, inclusive. Previous to 1904 the record was kept at Levan, 6 miles south of the substation, by a cooperative observer of the United States Weather Bureau. Since 1904 the record has been kept at the substation. The average annual precipitation near or at the Nephi substation for the past 15 years has been 13.6 inches.

TABLE I.—*Monthly and annual precipitation (in inches) in the Juab Valley, Utah, 1898 to 1912, with the average, maximum, and minimum for each month.*

Year, etc.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1898	0.80	0.25	1.45	1.06	5.57	0.90	1.62	0.73	0	0.99	0.94	1.36	15.67
1899	1.43	2.25	3.96	.71	1.75	.95	.25	1.06	0	2.07	1.09	1.91	17.43
1900	.87	.70	.12	3.70	.57	.04	.03	.28	1.70	.69	1.45	.19	10.34
1901	.93	2.23	1.88	1.02	1.74	.29	.25	1.55	.18	1.31	.53	1.40	13.31
1902	.53	1.41	2.41	1.20	.16	.03	.32	.20	.91	1.62	1.98	1.72	12.49
1903	1.64	.98	1.33	2.03	2.26	.48	.47	.15	.92	1.56	.24	.52	12.58
1904	.68	1.44	2.41	.80	3.10	.20	.36	.17	.20	1.05	0	.97	11.20
1905	.28	2.22	1.57	1.22	1.39	.21	.31	.60	3.17	.08	1.01	.57	12.63
1906	1.48	.68	3.83	2.87	2.92	.43	.80	1.57	.61	(1)	1.47	1.82	18.48
1907	1.90	2.01	1.42	.93	1.76	1.58	.32	1.46	.74	.84	.50	1.97	15.43
1908	.81	1.11	1.12	.29	3.64	.67	.52	3.41	2.28	1.73	.46	.62	16.66
1909	2.57	1.70	1.03	2.21	.68	.17	.95	2.84	.68	.32	1.53	1.51	16.19
1910	.61	.61	.81	.46	.72	.03	.38	.10	2.37	1.57	.58	.84	9.08
1911	1.92	.61	1.05	.56	.24	.76	1.77	.28	1.07	.75	.44	.66	10.11
1912	.39	.29	2.80	1.47	1.05	.17	.75	.35	.47	3.35	1.25	.27	12.61
Average	1.12	1.23	1.81	1.37	1.84	.45	.60	.98	1.02	1.19	.90	1.09	13.61
Maximum	2.57	2.25	3.96	3.70	5.57	1.58	1.77	3.41	3.17	3.35	1.98	1.97	18.48
Minimum	.28	.25	.12	.29	.16	.03	.03	.10	0	(1)	0	.19	9.08

[1] Trace.

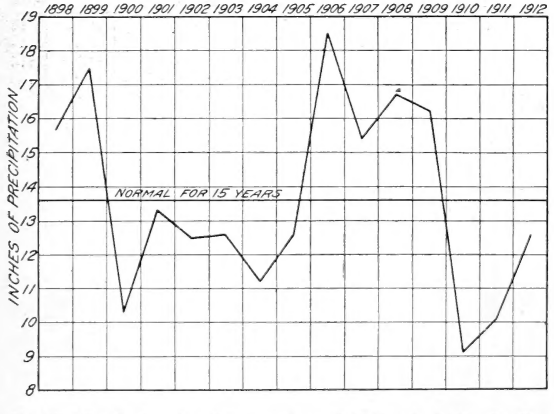

FIG. 5.—Graph showing the annual precipitation in inches for the 15-year period, 1898 to 1912, inclusive, at or near the substation, Nephi, Utah.

Table I shows that the maximum precipitation during the 15 years from 1898 to 1912, inclusive, was 18.48 inches (in 1906) and the minimum for the same period was 9.08 inches (in 1910). During that time the precipitation has been above normal six years, below normal nine years. This fact is shown graphically in figure 5.

Table I shows, further, that March, April, and May are the wettest months, May having the highest average, 1.84 inches. June and

July are by far the driest months. Most of the precipitation from November to March comes in the form of snow. The average monthly distribution of the annual precipitation at Nephi, 1898 to 1912, inclusive, is shown graphically in figure 6.

Since 1908 an accurate record of the daily rainfall at the Nephi substation has been kept. A summary of these data is presented in Table II, which shows the number of days in each month from 1908 to 1912 on which rain fell, the number on which the precipitation exceeded 0.5 inch, and the maximum and minimum rainfall on any one day.

TABLE II.—*Precipitation at the Nephi substation, 1908 to 1912, showing the number of days in each month on which rain fell, the number of days on which the precipitation exceeded 0.5 inch, and the maximum and minimum rainfall on any one day.*

Month, etc.	1908				1909				1910				1911				1912			
	Rainy days.		Inches of rain.		Rainy days.		Inches of rain.		Rainy days.		Inches of rain.		Rainy days.		Inches of rain.		Rainy days.		Inches of rain.	
	Total.	Over 0.5 inch.	Maximum.	Minimum.	Total.	Over 0.5 inch.	Maximum.	Minimum.[1]	Total.	Over 0.5 inch.	Maximum.	Minimum.[1]	Total.	Over 0.5 inch.	Maximum.	Minimum.[1]	Total.	Over 0.5 inch.	Maximum.	Minimum.[1]
January	4	0	0.37	0.03	6	1	1.30	0.13	6	0	0.20	0.01	4	1	1.38	0.10	4	0	0.13	0.07
February	5	0	.42	.10	5	2	.69	.06	4	0	.31	.04	5	0	.28	.05	3	0	.10	.09
March	4	1	.76	.03	6	0	.42	.03	2	1	.76	.05	2	2	.53	.52	8	3	.75	.05
April	2	0	.25	.04	6	2	.78	.12	4	0	.40	T.	4	0	.28	.05	10	1	.58	.03
May	9	3	1.15	.02	5	0	.46	.01	5	0	.27	T.	2	0	.17	.07	7	1	.55	.02
June	9	0	.21	.01	1	0	.17	.00	1	0	.03	.00	8	0	.43	T.	5	0	.11	T.
July	6	0	.22	.02	6	0	.37	.05	14	0	.15	T.	8	1	.65	T.	8	0	.36	.01
August	3	2	2.61	.10	13	3	.72	T.	8	0	.05	T.	3	0	.28	T.	7	0	.14	T.
September	6	2	1.41	.02	8	0	.15	.02	9	1	.61	T.	7	1	.72	T.	4	0	.44	T.
October	2	2	1.20	.53	2	0	.21	.11	5	1	.83	T.	4	0	.46	.07	12	1	1.17	T.
November	1	1	.46	.00	5	1	.90	.10	3	0	.43	.07	2	0	.31	.13	5	1	.51	.02
December	3	1	.53	.04	6	1	.50	.05	3	1	.65	.04	5	0	.23	.10	3	0	.14	.05
For the year:																				
Total	54	12	....	....	69	10	....	....	64	4	....	....	54	5	....	....	76	7	....	....
Maximum	9	3	2.61	....	13	3	1.30	....	14	1	.83	....	8	2	1.38	....	12	3	1.17	....
Minimum	1	0	....	0	1	0	....	.00	1	0	....	.00	2	0	....	T.	3	0	....	T.

[1] T=trace.

Table II shows that most of the rains falling at the Nephi substation are small and in many cases negligible. This fact is not so serious during the early or late months of the year when evaporation is slight, but from March to August any rain of less than 0.5 inch is practically useless in so far as direct benefit to the crop is concerned. It is not sufficient to more than saturate the dry surface of the soil and thus does not allow the addition by percolation of any moisture to that below. Because it remains in the surface few inches it is almost entirely lost by evaporation before the crop can make any use of it. Table II shows further that in June of the past five years there has been not one rain of as much as 0.5 inch. July has had one. This lack of rainfall in June and July often has a serious effect on the cereal crops, which at that time are passing from the boot to full

heading and ripening. During the past five years, however, there has been no such serious effect on the crops at the Nephi substation except in the case of spring grains. The season of 1910 was the most severe of any of the past five.

EVAPORATION.

Since 1908 the daily evaporation has been recorded for the months of April to October, inclusive. The method of determining the evaporation is that employed at all of the stations where the Biophysical Laboratory of the Bureau of Plant Industry has been cooperating; hence, the results obtained at Nephi are made directly comparable with those obtained at other points.[1]

FIG. 6.—Graph showing the average monthly precipitation in inches during the 15-year period, 1898 to 1912, inclusive, at the substation, Nephi, Utah.

The average evaporation at Nephi during the six summer months from April to September, inclusive, for the past five years has been 45.57 inches. This amount is practically an average of the amounts determined by the Biophysical Laboratory at the various dry-land experiment stations in the Great Plains area and westward.

The average daily evaporation by months and the monthly evaporation (in inches) at the Nephi substation for the six summer months of the five years from 1908 to 1912, with the 5-year averages, are given in Table III.

[1] Briggs, L. J., and Belz, J. O. Dry farming in relation to rainfall and evaporation, U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 188, p. 16–20, 1910.

TABLE III.—*Average daily and total monthly evaporation (inches) at the Nephi substation during each of the six summer months for five years, 1908 to 1912.*

Year.	Apr.	May.	June.	July.	Aug.	Sept.	Six months.
Average daily evaporation:							
1908	*0.16	*0.23	0.26	0.34	0.30	0.21	0.25
1909	.12	.19	.29	.31	.23	.19	.22
1910	.19	.24	.36	.32	.32	.20	.27
1911	.16	.27	.29	.28	.34	.22	.26
1912	.12	.20	.31	.30	.27	.21	.24
Average	.15	.23	.30	.31	.29	.21	.25
Total monthly evaporation:							
1908	*4.80	*6.98	7.87	10.52	9.34	6.23	45.74
1909	3.64	5.99	8.81	9.47	7.03	5.59	40.53
1910	5.82	7.46	10.90	9.98	10.09	6.01	50.26
1911	4.93	8.41	8.69	8.72	10.47	6.69	47.91
1912	3.54	6.30	9.28	9.24	8.89	6.16	43.41
Average	4.55	7.03	9.11	9.59	9.16	6.14	45.57

* The evaporation tank was not installed until June, 1908; hence, the evaporation for April and May, 1908, has been interpolated.

The lowest total evaporation, 40.53 inches, was recorded in 1909. The highest, 50.26 inches, was recorded in 1910. The high evaporation of 1910, coupled with the scarcity of rainfall, made that year a severe one in dry-land crop production. The lowest average daily evaporation has been recorded in April and the highest in July; however, there is little difference in the evaporations of June, July, and August.

WIND.

The anemometer used at the Nephi substation was not obtained until the spring of 1909, and for this reason a record of the wind for 1908 is not available. Since 1909 a complete record of the wind during April to October, inclusive, has been kept. The anemometer has stood next to the evaporation tank and has recorded the wind which has passed directly over the tank at a distance of about 2 feet from the surface of the ground. The average wind velocity (in miles per hour) during the months from April to October, inclusive, for the years 1909 to 1912, inclusive, is presented in Table IV.

TABLE IV.—*Average wind velocity (miles per hour) at the Nephi substation by months for the period from April to October for the years 1909 to 1912.*

Year.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Average.
1909	4.7	4.6	4.1	4.1	3.3	3.7	3.6	4.0
1910	5.3	4.6	5.4	4.4	4.4	3.9	3.2	4.5
1911	4.3	6.0	4.9	3.7	4.4	4.6	3.4	4.5
1912	4.4	5.2	4.8	4.3	3.9	4.1	3.2	4.3
Average	4.7	5.1	4.8	4.1	4.0	4.1	3.3	4.3

Table IV shows that the average wind velocity per hour at Nephi is comparatively low, and that there is little difference among the

monthly averages for the past four years. Strong winds at Nephi are very infrequent and no exceptionally high velocities have been recorded. The wind for any one day (24 hours) very seldom exceeds a total of 200 miles, while the average velocity does not exceed 10 miles an hour. The wind is usually from the south and southwest in the morning, but during the day it gradually changes until by evening it is blowing from the north and northeast. Protracted hot winds are practically unknown.

TEMPERATURE.

The maximum and minimum temperatures are determined daily at the substation from April 1 to October 31, inclusive. The work was started June 1, 1908. A maximum and a minimum thermometer, as well as an air thermograph, are in constant use during the summer months. A summary of the mean, maximum, and minimum temperatures during April to October, inclusive, for the past four years is presented in Table V.

TABLE V.—*Summary of mean, maximum, and minimum temperatures (° F.) at the Nephi substation by months from April to October for the years 1909 to 1912.*

Month.	Mean.					Maximum.					Minimum.				
	1909	1910	1911	1912	Average.	1909	1910	1911	1912	Average.	1909	1910	1911	1912	Average.
April	43	49	44	41	44	76	85	74	68	78	12	18	13	20	16
May	52	56	54	52	53	83	92	85	88	87	21	28	22	25	24
June	66	68	63	62	65	94	97	94	90	94	33	40	35	27	34
July	72	73	69	70	71	99	101	95	95	97	41	41	36	41	40
August	71	71	70	70	70	95	96	96	95	95	46	32	41	42	40
September	59	62	61	54	59	85	92	91	84	88	27	33	29	25	28
October	49	48	44	44	46	79	78	75	78	77	12	23	16	8	15

Table V shows that the highest average mean and maximum temperatures have been recorded in July, while the lowest have been recorded for April and October. Only three of the months, June to August, inclusive, have been free from frost. Table VI gives the dates of the last spring and first fall frosts and the number of days in the frost-free period during each year from 1908 to 1912, inclusive.

TABLE VI.—*Killing frosts at the Nephi substation for the years 1908 to 1912, with temperatures recorded and length of frost-free period.*

Year.	Last in spring.		First in fall.		Frost-free period.
	Date.	Minimum temperature.	Date.	Minimum temperature.	
		° F.		° F.	*Days.*
1908	June 22	30	Aug. 30	31	69
1909	May 30	30.5	Sept. 12	30.5	105
1910	May 16	28	Oct. 5	29	142
1911	May 27	28	Sept. 17	29	113
1912	June 16	31	Sept. 4	30	80
Average	June 4	29.5	Sept. 14	29.9	102

EXPERIMENTAL WORK.

In all the varietal tests of cereals at Nephi the primary object has been to determine the relative yielding power of the varieties. In addition, efforts have been made to find reasons for the existing wide variations in yield. In order to make these studies complete, it was necessary to divide the work into plat and nursery experiments. The plat experiments were designed to conform as nearly as possible to the farm practices in the Great Basin area. On these plats the crops were studied on an extensive scale. In the nursery tests, which were confined to short rows, the crops were studied intensively. The rows were uniformly spaced and a known number of seeds were planted at definite distances in the row. This method afforded a means of making a thorough study of several individual plants of each variety.

In this bulletin the results of the plat experiments are presented in detail. The report of the nursery work is general, and only those results which can be correlated with the results obtained in the plats are given special attention.

PLAT EXPERIMENTS.

Dimensions of Plats.

Most of the field tests were conducted on tenth-acre plats 36 feet wide by 121 feet long. A few plats were one-fifth acre in area, or 72 by 121 feet, while others were one-twentieth of an acre each, either 18 by 121 feet or 36 by 60.5 feet. The plats lay side by side in series, which extended north and south, and they were separated by 5-foot alleys. The series of plats were in pairs, separated by a 5-foot alley, while the pairs of series were separated by a 13-foot road. Each plat was thus bounded on both sides and on one end by 5-foot alleys and on the other end by a 13-foot road. All plats used for the varietal tests were alternately fallowed and cropped.

Treatment of Plats.

In October of the year when the plats were cropped all the series of cropped plats were plowed to a depth of about 8 inches, the stubble being turned under. They were then allowed to lie untouched until the following spring. In most years a heavy growth of volunteer cereals and weeds necessitated a replowing in the spring. Sometimes a double disking would take the place of the second plowing. In all cases sufficient spring cultivation was given the fallow plats to destroy all plant growth. After the plowing or disking had been completed a "float," or leveler, was dragged over the plats at right angles to the plowing to level the surface of the ground.

During the remainder of the fallow season a spike-tooth harrow was used to break any crust which formed after a rain. Occasionally

a hoe was used to kill scattered weeds and other plant growth. Just previous to the time the plats were planted they were usually harrowed again.

Seeding was done with a 6-foot single-disk press drill with seed spouts 7 inches apart. The seed was planted uniformly at what was considered the best rate and was placed at a depth of 1.5 to 3 inches. It had previously been treated for bunt (smut) with a solution containing 1 pound of formalin to 50 gallons of water, in which it had been soaked for 10 minutes and then dried. The sowing was done usually between October 1 and 15 and was completed in two to three days. After seeding, the plats were not cultivated until the following spring.

When the plants were about 4 to 6 inches high the plats were harrowed with a spike-tooth harrow. The teeth of the harrow were slanted backward in order to lessen the injury to the plants, and the harrowing was crosswise of the drill rows. No further cultivation was given the plats. The plats were rogued each year in order to keep the varieties as pure as possible.

The harvesting was done with a binder. The bundles were shocked and the plats later were raked. This raking insured against loss and error due to fallen and scattered heads. Those gathered by the rake were added to the shock. The shocks stood in the field for two to four weeks before they were thrashed.

Check Plats.

Check plats were used in determining the comparative or computed yields of the varieties. Several plats located at various points on the farm were planted to one variety of winter wheat. These plats received identical treatment and were called check plats. It was believed that the average yield of these check plats would equal the average yield of the variety used on them had it been grown exclusively on all parts of the farm. Then, by knowing the plat yield of any one variety, its average yield per acre in terms of the check variety could be computed with reasonable accuracy. The difference between the yield of any one check plat and the average yield of all check plats was used to express the relative difference which would exist in case any other variety were occupying the place of the check variety. Thus, if the difference were ± 5 bushels per acre, that difference would be added to or subtracted from the actual yields secured from any given one of the varieties in the vicinity of the single check plat. This would give the average yield of the given variety if it were grown on the entire farm. In order to facilitate computations the following equation was constructed:

a=yield of nearest check plat.
b=average yield of all check plats.
x=actual yield of nearest variety.
y=computed yield of nearest variety.
$y=x+(b-a)$.

In 1908, 7 check plats of Koffoid wheat (C. I. No. 2997) were used. This number was found to be too few, because they had to be scattered so widely that they did not represent the true value of soil variations. This was the case also in 1909, when 8 checks of the same variety were used. In 1910, 23 checks of Turkey wheat (C. I. No. 2998) were used and more accurate computations were made. Seldom were there more than 7 varietal plats between any 2 checks. In 1911 and 1912 about the same number of checks was used as in 1910.

The check-plat system described above did not prove as satisfactory as was hoped. It afforded a means of gaining a better idea of the relative yielding power of the several varieties than would be possible without the use of any system designed for that purpose. But the checking system used at Nephi was lacking in accuracy. The yields of the various check plats were influenced by so many uncontrollable factors (soil variation, winterkilling, weeds, etc.) that to assume that any one of the other varieties would be affected to a like degree would be more a theory than a determination. Though the check yields were fairly uniform in many instances, occasionally there would be a variation as great as 100 per cent. More than this, the variety growing on a plat next to a low-yielding check plat sometimes would yield very high. In the latter case the computed yield of the variety would necessarily fall far below its actual yield. In other cases the reverse condition would exist and the computed yield of the variety would greatly exceed its actual yield. Such instances show the inaccuracy of the checking system used.

It is believed that a replication of plats devoted to a test of any one variety would be far more dependable as a means of showing the relative yielding power of that variety than would the check-plat system. Where a replication of plats is practiced, the number of varieties tested might necessarily be reduced. Then, too, more work in connection with the varietal test would be necessitated, but the accuracy of the results obtained would compensate for the extra labor involved.

The computed yields of the winter varieties grown at Nephi during the years 1908 to 1911, inclusive, are reported in connection with the absolute yields, but only for the purpose of comparison.

Collection of Data.

Throughout the entire season the behavior of the crops on the plats in the varietal test was observed closely. In the spring, after it was reasonably certain that no more plants would appear, the number

of thousand plants to the acre was determined for each variety.[1] Then the vigor, color, manner of growth, date of heading, date of ripening, height, and date of harvesting were noted, each in its turn. All the significant data thus obtained will be presented in their proper places during the ensuing discussion of the various cereals.

A small separator with a 20-inch cylinder was used in thrashing. To determine the yields of the plats the total weight of the crop from each plat was first obtained. After thrashing, the weight of the grain was noted and this was subtracted from the total weight in order to determine the weight of the straw and chaff. The weighings were made at the thrashing machine, one just before and the other immediately after the grain was thrashed. Multiplying the weight of the grain from each plat by 5, 10, or 20, according to the size of the plat, gave the total weight of grain per acre. This weight divided by the standard bushel weight gave the actual yield to the acre in bushels.

Varietal Tests.

The plat tests have included 105 varieties and strains of cereals. There were 68 varieties and strains of winter wheat, 1 winter oat, 3 winter barleys, 2 winter emmers, 10 spring wheats, 7 spring oats, and 14 spring barleys.[2]

The Utah Agricultural Experiment Station had conducted varietal tests at Nephi previous to cooperation. They had tested 9 common winter wheats, 3 durum varieties planted in the fall, 1 common spring wheat, and 3 spring durums. Tests had been made also of 4 varieties of oats, including 1 winter variety, and with 3 varieties of barley. Some very satisfactory results had been obtained with these cereals, but the test was of a duration too short to be conclusive. These varieties were therefore continued after cooperation in addition to the varieties brought from other stations.

WHEAT.

It is generally agreed that the Intermountain States comprise a winter-wheat area. Farmers have recognized this fact for years, and experimental results furnish conclusive evidence in that respect. Spring wheats are sown only occasionally, when the farmer has been unsuccessful in getting all his land sown to winter wheat or when extensive winterkilling of the fall-sown wheats necessitates reseeding the land in the spring. In the latter case it is considered better to get a small crop of spring wheat than no crop at all.

[1] See page 23 for an explanation of the method used in making these determinations.

[2] Eleven of these are spring barleys which have been grown at the Arlington Experimental Farm, near Washington, D. C., for several years as winter varieties. They were planted at Nephi in the fall of 1911, but are not yet considered winter varieties at this station.

The wheat work at Nephi has been confined almost entirely to the testing of winter varieties. A rather detailed report of the results obtained is given on the following pages.

Winter Wheat.

Of the 68 varieties and strains of winter wheat tested, 57 have been introduced since cooperation began on July 1, 1907. Previous to that time only 11 varieties were under test. The 3 best known and highest yielding varieties of the 11 originally tested were Gold Coin, Koffoid, and Turkey. These were later given the Cereal Investigation numbers 2996, 2997, and 2998, respectively. The average yields of these varieties for 1904 to 1906, inclusive, were 15.09, 18.25, and 24.96 bushels per acre, respectively.[1]

The 57 winter-wheat varieties which were introduced after cooperation began were obtained from the following places in quantities sufficient to sow a tenth-acre plat:

	Varieties.
McPherson, Kans., C. I. Experiment Farm, 1907	42
Modesto, Cal., Cooperative Farm, 1907	6
Bellefourche, S. Dak., Bellefourche Experiment Farm, 1907	1
Alberta, Canada, Lethbridge Experiment Station, 1907	1
Mona, Utah, farmer, 1907	1
Rieti, Italy, through the Office of Seed and Plant Introduction, 1908	1
Salina, Kans., through Intermountain Milling Co., 1908	1
Montana, through Farmers' Cash-Buyers' Union, 1908	1
Newton, Utah, farmer, 1911	1
Worland, Wyo., Prof. B. C. Buffum, 1911	2
Total	57

Grain yields of winter wheat.

The average yield in bushels per acre of all the varieties of winter wheat tested at Nephi in 1908 was 25.4; in 1909, 11.1; in 1910, 11.6; in 1911, 23.1; and in 1912, 18.3. This wide variation is due to the influence of the physical factors which already have been discussed. When there was considerable precipitation in the fall so that the crops were up and well prepared for entering the winter, when snow protected them from winterkilling, and when the stands were thick enough to keep out weeds, the yields were much higher than when the opposite conditions existed.

After obtaining the yields of 1911 the varieties were all ranked according to their average actual and average computed yields for four years, 1908 to 1911, inclusive. It was believed that they had been given a fair test, and it was time to begin discarding the inferior varieties in order to make room for a more thorough test of the superior ones. The rank of the varieties based on their average actual

[1] Jardine, W. M. Arid farming investigations. Utah Agricultural Experiment Station, Bulletin 100.

yield and also their rank based on their average computed yield for the same 4-year period are shown in Table VIII. A brief discussion of the results of each year will be given.

Results in 1908.—Fifty-eight varieties and strains of winter wheat were planted on tenth-acre plats in the fall of 1907. The average acre yield in 1908 of the 8 varieties which were grown at Nephi in 1907 was 27.2 bushels, or 3.8 bushels below the average yield of the same varieties in 1907. The average acre yield in 1908 of the 42 varieties which were introduced from Kansas in 1907 was 26.3 bushels; while the average yield of the 5 varieties from California was 14.3 bushels per acre. The low yields of the California varieties undoubtedly were due to their inability to survive the winter conditions, as there was a high percentage of winterkilling among them. It is interesting to compare the yields in 1908 of all varieties at Nephi with their yields in 1907 and 1908 in the States from which they were brought. These data are presented in Table VII.

TABLE VII.—*Winter wheat varieties grown at the Nephi substation, Utah, in 1908, showing their origin, the source of seed planted, and the yields in 1907 and 1908 at their source compared with their yields in 1908 at Nephi.*

C. I. No.	Variety.	Origin.	Source of seed.	Yields (bushels per acre) at—		
				Source in 1907.	Nephi in 1908.	Source in 1908.
2998	Turkey	Russia	Nephi, Utah	37.7	35.0	.....
2999	White Club	Utah (?)	do	29.0	28.0	.....
2996	Gold Coin	Eastern United States.	do	29.5	27.7	.....
3000	Bluestem	Utah (?)	do	31.8	25.8	.....
2997	Koffoid	Utah	do	38.2	24.3	.....
2100	Black Don[1]	Russia	do	23.0	17.5	.....
.....	Hard winter	Algeria	do	27.9	26.0	.....
1667	Beloglina	Russia	do	30.7	33.3	.....
	Average of 8 varieties from Nephi, Utah			31.0	27.2	.....
1355	Armavir	Russia	McPherson, Kans.	19.5	28.3	12.5
1395–2	Diehl Mediterranean	.....	do	18.9	27.2	18.3
1432	Crimean	Crimea	do	18.7	30.7	16.5
1433	do	do	do	15.6	27.5	14.0
1435	do	Don Territory, Russia.	do	22.2	25.8	17.3
1436	do	Crimea	do	18.7	30.2	11.5
1437	do	Taurida, Russia	do	21.8	30.3	14.5
1438	Ghirka Winter	do	do	18.8	27.7	14.0
1439	Ulta	Caucasus	do	18.1	28.3	14.2
1442	Kharkof	Kharkof, Russia	do	20.9	26.2	19.5
1532	Red Russian	Southern Russia	do	16.1	21.8	18.0
1539	Torgova	Northern Russia	do	17.4	11.0	16.7
1543	Beloglina	do	do	15.8	10.2	17.2
1544	do	do	do	12.8	15.0	14.7
1558	Turkey	Crimea	do	13.5	26.2	17.8
1559	Crimean	do	do	23.6	29.2	15.8
1560	Banat	Hungary	do	16.4	22.7	17.0
1561	Theiss	do	do	17.5	24.5	16.2
1562	Baeska	do	do	13.5	34.0	16.0
1563	Weissenberg	do	do	13.1	32.7	10.3
1564	Pesterboden	do	do	17.5	30.0	14.2
1571	Turkey	Russia	do	20.6	33.0	20.3
1583	Kharkof	do	do	20.6	31.0	19.1
1656	Roumanian	Roumania	do	15.1	24.5	11.7
1658	do	do	do	15.7	23.3	13.4
1662	do	do	do	16.9	25.7	14.1
1676	Servian	Servia	do	13.8	22.7	12.7
1691	Bosnian	Bosnia	do	15.3	19.2	13.8
1739	Budapest	Hungary	do	15.1	21.2	15.6

[1] Grown as a winter durum at Nephi.

TABLE VII.—*Winter wheat varieties grown at the Nephi substation, Utah, etc.*—Cont'd.

C. I. No.	Variety.	Origin.	Source of seed.	Yields (bushels per acre) at—		
				Source in 1907.	Nephi in 1908.	Source in 1908.
1756	Hard winter	Missouri	McPherson, Kans.	14.5	32.2	12.8
1757	Japanese Velvet Chaff	Japan	do	11.4	23.5	15.0
1783	Hard winter	Oklahoma	do	11.3	29.8	14.7
1784	do	do	do	8.8	26.3	16.3
1787	Japanese	Japan	do	8.5	25.5	(1)
1788-1	Japanese Square Head	do	do	8.3	23.5	(1)
1824	Zimmerman×Turkey	Kansas hybrid	do	12.6	30.0	15.5
2034	Hungarian	Hungary	do	10.5	31.3	14.3
2042	do	do	do	10.0	32.7	13.0
2048	Bulgarian	Bulgaria	do	12.0	32.5	13.8
2906	Currell	Oklahoma	do	7.1	19.7	14.1
2907	Zimmerman	Kansas	do	7.2	24.8	8.5
2908	Malakof	Russia	do	17.4	31.5	12.2
	Average of 42 varieties from McPherson, Kans			15.3	26.3	14.9
1596	Fretes	Algeria	Modesto, Cal	13.5	17.3	67.3
3018	Salt Lake Club	California	do	10.3	13.8	33.6
2985	Bluestem	Washington	do	7.3	14.3	42.0
3019	White Australian	California	do	17.6	20.5	51.3
2986	California Gem (293–'04)	do	do	10.3	15.5	23.0
	Average of 5 varieties from Modesto, Cal			11.8	16.3	43.5

[1] Discarded after 1907.

In Table VII is shown a wide variation in the yields of the varieties at the different places. The Nephi wheats yielded less in 1908 than they did in 1907. The Kansas wheats yielded much more at Nephi in 1908 than they did at McPherson in either 1907 or 1908, while the California wheats yielded much less than they did at Modesto in 1908, though more than in 1907. Some of the varieties which yielded well in Kansas in 1907 yielded much less at Nephi in 1908, and in other cases the reverse was true. It is interesting to note that the average yield of the Kansas wheats grown at Nephi in 1908 was approximately the same as that of the Nephi wheats.

Results in 1909.—In addition to those varieties which were grown at Nephi in 1908, three new varieties were sown in the fall of that year. These were Rieti (C. I. No. 2942, S. P. I. No. 17994), from Italy; Turkey, from near Salina, Kans.; and Turkey, from Montana. In addition to these, the two following varieties, which had been grown in 1907 but not in 1908, were sown, namely, Odessa (C. I. No. 3274), a soft, amber-grained, brown-chaffed variety; and Lofthouse (C. I. No. 3275), a soft, white-grained, white-chaffed variety. Thus the 1909 varietal test included 63 varieties, grown in tenth-acre plats.

The yields in 1909 were generally much lower than those of 1908. It is believed that this was due to winterkilling, which will be discussed later. The stand on many of the plats was thin, and as a

result considerable weed growth was made possible. The yields per acre of the varieties ranged from 1.16 bushels of Koffoid (one Koffoid plat yielded so little that it could not be thrashed) to 23.33 bushels of Japanese (C. I. No. 1787). The latter was grown on the "old field,"[1] and can not be safely compared with the yields of the other varieties which were grown on the "Richie field."

Results in 1910.—In the fall of 1909, 61 varieties of winter wheat were planted. The only varieties discarded in 1909 were the Turkey from near Salina, Kans., and the Turkey from Montana, neither of which yielded satisfactorily.

The yields of 1910 were about the same as those of 1909. The low yields were accounted for at that time in the following manner:

> The winter of 1909–10 was a peculiar one in some ways. The ground received an early covering of snow, which, periodically increased, remained until March. The temperature was generally low throughout the winter season. With the first days of March came a rather sudden change from cold to warm weather. Such a change has been decidedly uncommon in the Juab Valley, and it was claimed by many that the thinning of what at first appeared to be a good stand of grain was due to the injury done to the young roots by the sudden changes in soil temperatures. That there was a thinning is quite certain, but the condition named may not explain its occurrence.

The highest yield per acre in 1910 was 21.2 bushels for Kharkof (C. I. No. 1583), and the lowest yield was 0.5 bushel for Black Don (durum, C. I. No. 2100), Silver Club (C. I. No. 3001), and the hard winter from Algeria, which had been grown at Nephi previous to 1908.

Results in 1911.—Six of the varieties grown in 1910 were discarded that year, leaving 55 varieties. The discarded varieties were C. I. No. 1784 (hard winter from Oklahoma), Bluestem (C. I. No. 2985), California Gem (C. I. No. 2986), Silver Club (C. I. No. 3001), Salt Lake Club (C. I. No. 3018), and Rieti (C. I. No. 2942). All other varieties were sown again in the fall of 1910.

The yields of 1911 were very satisfactory, because of exceptionally favorable weather conditions during the entire season. The fall of 1910 was ideal. The fall-sown cereals were able to make good growth before the snows of winter covered them. The following winter was a mild one, and consequently there was little winterkilling. The spring of 1911 was rather cold, but no damage by frost was noted. The precipitation of April and May was below normal, but that of June was above normal. All of these factors were favorable to high yields.

The highest acre yield in 1911 was 32.7 bushels for Koffoid (C. I. No. 2997) and the lowest yield was 3.8 bushels for the Algerian hard winter.

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[1] Originally the farm consisted of 40 acres. In 1908, 15 acres were added on the south side and 47 acres were added on the west side. These fields are referred to as the "old field" (original), the "Richie field" (south addition), and the "Kendall field" (west addition).

After obtaining the yields of 1911 the varieties were all ranked according to their average actual and average computed yields for the four years 1908 to 1911, inclusive. The results are given in Table VIII.

TABLE VIII.—*Annual and average yields of 60 varieties of winter wheat at the Nephi substation in a 4-year test, 1908 to 1911, inclusive.*

RANKED ACCORDING TO THEIR AVERAGE ACTUAL YIELDS.

Rank.	C. I. No.	Variety.	Yield (bushels per acre).				
			1908	1909	1910	1911	Average.
1	1437	Crimean	30.33	18.66	20.30	26.70	23.99
2	1442	Kharkof	26.16	19.16	17.00	27.20	22.38
3	1439	Ulta	28.33	18.00	17.50	24.70	22.13
4	2998	Turkey	35.00	16.16	[1] 15.80	[2] 21.45	22.10
5	1559	Crimean	29.16	14.00	15.20	29.70	22.01
6	1435	do	25.83	20.33	15.30	25.20	21.66
7	1558	Turkey	26.16	19.66	12.30	28.50	21.65
8	2979	Alberta Red	34.33	14.33	12.80	24.20	21.41
9	1787	Japanese	25.50	23.33	12.30	24.20	21.33
10	1438	Ghirka Winter	27.66	15.66	12.20	29.50	21.25
11	1355	Armavir	28.33	21.33	14.00	21.00	21.16
12	2048	Bulgarian	32.50	13.00	7.80	31.20	21.12
13	1571	Turkey	33.00	15.33	20.50	14.70	20.88
14	1583	Kharkof	31.00	10.66	21.20	20.50	20.84
15	1563	Weissenberg	32.66	13.83	16.30	20.30	20.77
16	1436	Crimean	30.16	14.66	15.50	22.20	20.63
17	1562	Bacska	34.00	13.00	16.70	17.70	20.35
18	2034	Hungarian	31.33	12.50	8.50	27.70	20.01
19	1756	Hard winter (Mo.)	32.16	17.33	11.50	19.00	19.99
20	1560	Banat	22.66	14.50	13.50	27.90	19.64
21	1432	Crimean	30.66	11.16	14.50	22.00	19.58
22	3055	Turkey	34.16	12.33	5.30	26.40	19.55
23	2908	Malakof	31.50	11.33	11.70	23.30	19.46
24	1564	Pesterboden	30.00	11.66	18.00	19.00	19.44
25	2996	Gold Coin	27.66	17.00	10.70	21.20	19.14
26	1676	Servian	22.66	15.66	10.50	27.40	19.05
27	1783	Hard winter (Okla.)	29.83	11.50	9.00	25.00	18.83
28	2042	Hungarian	32.66	8.83	8.80	24.70	18.75
29	1656	Roumanian	24.50	10.00	15.50	24.50	18.62
30	1532	Red Russian	21.83	14.66	14.80	22.70	18.50
31	2999	White Club	28.00	8.16	5.80	31.50	18.36
32	1667	Beloglina	33.33	9.33	13.50	17.20	18.34
	1824	Zimmerman × Turkey	30.00	3.16	9.70	30.50	
33	2906	Currell	19.66	21.83	10.70	20.70	18.22
34	1433	Crimean	27.50	8.66	13.00	23.30	18.11
35	1662	Roumanian	25.66	13.50	16.70	16.50	18.09
36	1561	Theiss	24.50	7.83	14.50	25.50	18.08
37	1395	Diehl Mediterranean	27.16	10.66	8.70	25.40	17.98
38	1658	Roumanian	23.33	11.16	13.80	23.30	17.90
39	2907	Zimmerman	24.83	10.33	11.30	24.30	17.69
40	1739	Budapest	21.16	12.66	7.30	25.50	16.65
41	3000	Bluestem	25.83	6.50	7.00	26.70	16.51
42	1539	Torgova	11.00	16.50	14.20	23.50	16.30
43	1596	Fretes	17.33	14.50	6.30	26.20	16.08
44	1544	Beloglina	15.00	15.16	12.00	21.50	15.91
45	3019	White Australian	20.50	10.66	3.50	27.00	15.41
46	1788	Japanese Square Head	23.50	9.66	4.30	21.50	14.74
47	1691	Bosnian	19.16	9.00	8.30	20.80	14.31
48	1543	Beloglina	10.16	12.16	8.80	24.90	14.00
49	2997	Koffoid	17.78	2.49	.80	32.70	13.44
50	1757	Japanese Velvet Chaff	23.50	9.66	4.30	15.10	13.14
51	2086	Pelissier	26.00	12.83	.50	3.80	10.78
52	2100	Black Don	17.50	4.83	.50	15.50	9.58
.....	1784	Hard winter (Okla.)	26.33	2.33	2.50	Discarded.	
.....	2985	Bluestem	14.33	4.83	2.33		
.....	2986	California Gem	15.50	3.33	.80		
.....	3001	Silver Club	11.00	3.66	.50		
.....	3018	Salt Lake Club	13.83	11.66	1.00		
.....	3274	Odessa	.....	11.16	10.00	24.20	.....
.....	3275	Lofthouse	.....	3.33	11.50	27.30	.....

[1] Average of 23 checks.

[2] Average of 22 checks.

TABLE VIII.—*Annual and average yields of 60 varieties of winter wheat, etc.*—Cont'd.

RANKED ACCORDING TO THEIR AVERAGE COMPUTED YIELDS.

Rank.	C. I. No.	Variety.	Yield (bushels per acre).				
			1908	1909	1910	1911	Average.
1	1437	Crimean	32.76	18.99	14.90	28.60	23.81
2	2979	Alberta Red	36.76	15.76	15.06	16.40	23.15
3	2998	Turkey	37.43	17.49	15.80	21.45	23.04
4	1563	Weissenberg	32 92	14.16	13.40	31.60	23.02
5	1559	Crimean	32.84	14.33	12.30	31.60	22.77
6	1562	Bacska	34.26	13.33	13.80	29.60	22.60
7	1355	Armavir	32.01	16.32	11.10	27.60	21.76
8	1558	Turkey	29.84	14.65	11.80	30.40	21.67
9	3055	.....do	36.59	13.66	8.90	26.00	21.29
10	1442	Kharkof	28.59	19.49	11.60	24.60	21.07
11	1564	Pesterboden	30.26	11.99	11.60	30.30	20.89
12	1439	Ulta	30.76	18.33	12.10	22.10	20.82
13	1435	Crimean	28.26	15.32	12.40	27.10	20.77
14	1662	Roumanian	25.92	13.83	14.70	26.30	20.19
15	1432	Crimean	34.34	6.15	11.60	28.60	20.17
16	1438	Ghirka Winter	30.09	16.15	9.40	24.90	20.13
17	1756	Hard winter (Mo.)	27.42	18.66	9.50	24.10	19.92
18	1560	Banat	26.34	14.83	10.60	26.00	19.44
19	1787	Japanese	20.76	17.01	12.80	26.30	19.22
	1436	Crimean	32.59	9.65	10.10	24.10	
20	1571	Turkey	33.26	15.66	13.50	13.90	19.08
21	1532	Red Russian	25.21	14.99	9.40	26.40	19.07
22	1583	Kharkof	31.26	10.99	14.20	19.70	19.04
23	2908	Malakof	23.76	11.66	11.50	28.40	18.83
24	1676	Servian	22.92	16.99	8.50	26.60	18.75
25	2996	Gold Coin	30.09	17.49	11.20	15.40	18.54
26	2048	Bulgarian	24.76	13.33	7.60	27.20	18.22
27	2999	White Club	30.43	10.65	5.90	25.70	18.17
28	2034	Hungarian	23.59	12.83	8.30	26.80	17.90
29	1783	Hard winter (Okla.)	25.09	11.83	7.00	26.90	17.70
30	1395	Diehl Mediterranean	31.84	13.15	5.90	19.60	17.62
31	1561	Theiss	26.93	8.16	11.60	23.60	17.57
32	3019	White Australian	24.18	11.15	4.60	29.20	17.28
33	1667	Beloglina	25.59	9.66	11.50	22.30	17.26
34	1433	Crimean	29.93	3.65	10.10	25.20	17.22
35	1539	Torgova	14.68	16.83	8.80	27.20	16.88
36	3000	Bluestem	28.26	8.99	8.10	20.90	16.56
37	1824	Zimmerman × Turkey	25.26	3.65	10.80	25.20	16.23
38	1544	Beloglina	18.68	10.15	11.50	23.40	15.93
39	2042	Hungarian	24.92	9.16	8.60	20.70	15.84
40	1656	Roumanian	24.76	10.33	8.50	19.40	15.75
41	1739	Budapest	16.42	13.99	5.30	24.70	15.10
42	1658	Roumanian	23.59	11.49	6.80	18.20	15.02
43	2906	Currell	11.92	15.51	7.10	22.80	14.33
44	2907	Zimmerman	17 09	10.82	8 50	19 70	14.03
45	1543	Beloglina	13.84	7.15	8.30	26.80	14.02
46	1596	Fretes	21.01	14.83	0	25.40	12.81
47	1691	Bosnian	14.42	10.33	6.30	20.00	12.76
48	1788	Japanese Square Head	18.76	12.15	4.40	15.70	12.75
49	2997	Koffoid	17.78	2.49	.90	26.90	12.02
50	1757	Japanese Velvet Chaff	18.76	12.15	4.40	9.30	11.15
51	2086	Pelissier	18.26	13.16	.30	8.90	10.15
52	2100	Black Don	9.76	5.36	1.60	10.20	6.72
.....	1784	Hard winter (Okla.)	21.59	4.82	2.60		
.....	2985	Bluestem	18.01	7.32	0		
.....	2986	California Gem	19.18	5.82	0	Discarded.	
.....	3001	Silver Club	14.68	6.15	1.60		
.....	3018	Salt Lake Club	17.51	12.15	2.10		
.....	3274	Odessa	.....	11.65	11.50	18.40	.....
.....	3275	Lofthouse	.....	3.82	12.50	21.50	.....

As seen in Table VIII, there is little difference between the relative rank of the varieties based on their average actual yield and on their average computed yield. The rank of the varieties is changed a little in the second part of the table, but it will be observed that most of the varieties leading in actual yield, though their relative position may be changed, also lead in computed yield. It will be observed,

also, that all of the leading varieties are of the hard winter group and most of them were introduced at the station since 1907.

After ranking the varieties in the manner described most of those ranking below the thirtieth position were discarded from the plat tests. The others were sown in the fall of 1911. A few varieties which are popular with the farmers in the Mountain States were continued in the plat test despite their low rank.

Results in 1912.—The fall of 1911 was very dry, and seeding was delayed considerably. After it had been finally accomplished extremely cold weather set in and it is believed that there was a great deal of fall killing. The winter, too, was dry and cold. As a result of this weather a very poor stand was obtained on the plats of winter grains, and the yields were low in comparison with those of 1911. The highest yield per acre in 1912 was 22.8 bushels for Bulgarian (C. I. No. 2048), and the lowest yield per acre was 5.8 bushels for Ulta (C. I. No. 1439).

Summary of winter wheat yields.—The rank of the best yielding winter wheat varieties grown at Nephi from 1908 to 1912, inclusive, is shown in Table IX, where they are ranked according to their average actual yields. The check plats of 1912 were so badly winter-killed that their yields are not dependable for use in figuring the computed yields of the other varieties, so no 5-year rank on computed yields is available.

TABLE IX.—*Annual and average yields of 28 varieties of wheat grown at the Nephi substation for five years, 1908 to 1912, ranked according to their average actual yields.*

Rank.	C. I. No.	Variety.	Yield (bushels per acre).					
			1908	1909	1910	1911	1912	Average.
1	1437	Crimean	30.33	18.66	20.30	26.70	19.50	23.10
2	2998	Turkey	35.00	16.16	[1] 15.80	[2] 21.45	22.10	22.10
3	1442	Kharkof	26.16	19.16	17.00	27.20	19.80	21.86
4	1559	Crimean	29.16	14.00	15.20	29.70	19.90	21.59
	1355	Armavir	28.33	21.33	14.00	21.00	22.30	
5	2048	Bulgarian	32.50	13.00	7.80	31.20	22.80	21.46
6	1438	Ghirka Winter	27.66	15.66	12.20	29.50	22.10	21.42
7	1435	Crimean	25.83	20.33	15.30	25.20	19.10	21.15
8	1571	Turkey	33.00	15.33	20.50	14.70	22.10	21.13
9	2979	Alberta Red	34.33	14.33	12.80	24.20	19.70	21.07
10	1583	Kharkof	31.00	10.66	21.20	20.50	21.40	20.95
11	1787	Japanese	25.50	23.33	12.30	24.20	18.40	20.75
12	1436	Crimean	30.16	14.66	15.50	22.20	19.30	20.36
13	1563	Weissenberg	32.66	13.83	16.30	20.30	17.70	20.16
14	1562	Bacska	34.00	13.00	16.70	17.70	17.80	19.84
15	1756	Hard winter (Missouri)	32.16	17.33	11.50	19.00	17.80	19.56
16	1564	Pesterboden	30.00	11.66	18.00	19.00	18.30	19.39
17	2034	Hungarian	31.32	12.50	8.50	27.70	16.90	19.38
18	1656	Roumanian	24.50	10.00	15.50	24.50	22.00	19.30
19	1432	Crimean	30.66	11.16	14.50	22.00	16.00	18.86
20	1439	Ulta	28.33	18.00	17.50	24.70	5.80	18.85
21	2908	Malakof	31.50	11.33	11.70	23.30	15.30	18.63
22	1676	Servian	22.66	15.66	10.50	27.40	16.80	18.60
23	1783	Hard winter (Oklahoma)	29.83	11.50	9.00	25.00	17.50	18.57
24	1560	Banat	22.66	14.50	13.50	27.90	13.80	18.47
25	3055	Turkey	34.16	12.33	5.30	26.40	13.90	18.42
26	1532	Red Russian	21.83	14.66	14.80	22.70	14.70	17.74
27	2996	Gold Coin	27.66	17.00	10.70	21.20	10.10	17.33

[1] Average of 23 check plats.

[2] Average of 22 check plats.

With two exceptions, all of the varieties reported in Table IX belong to the hard winter group of wheats. Except for Ghirka Winter (C. I. No. 1438), which is not bearded, these hard varieties are bearded, white chaffed, and red grained.

The two varieties which do not belong to the hard group are Japanese (C. I. No. 1787), eleventh in rank, and Gold Coin (C. I. No. 2996), lowest in rank. The Japanese is a beardless, brown-chaffed, soft, amber-grained variety, and Gold Coin is beardless, brown chaffed, soft, and white grained. It will be remembered that Gold Coin is one of the most popular winter wheats in the Intermountain States.

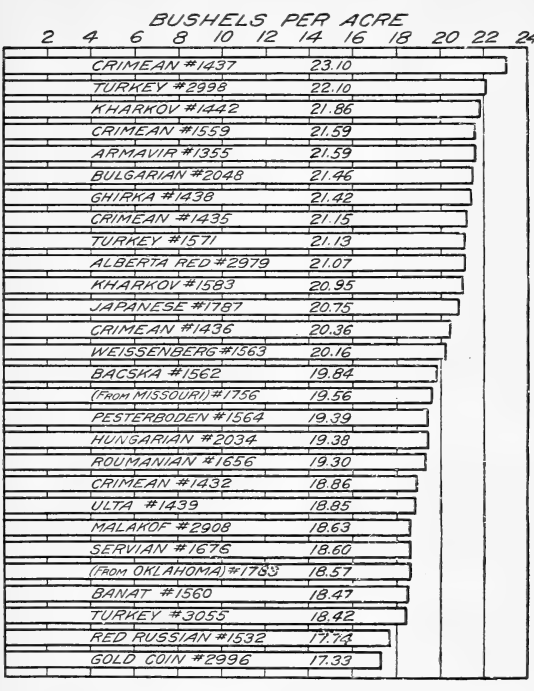

FIG. 7.—Diagram showing the average yields of 28 winter-wheat varieties for five years, 1908 to 1912, inclusive, at the substation, Nephi, Utah.

A clearer understanding of the relative average yield of the varieties listed in Table IX can be gained by studying figure 7, which shows graphically their average yields for the five years 1908 to 1912.

MISCELLANEOUS DATA ON WINTER WHEATS.

After the grain yields of the winter-wheat varieties have been considered, the data most significant in making comparisons are (1) the stand, (2) the date of heading, (3) the date of ripening, (4) the height, (5) the ratio of grain to straw, and (6) the bushel weight of the grain. A summary of these data for the past five years is presented in Table X, each factor of which will be considered separately.

TABLE X.—*Average miscellaneous data on the leading varieties of winter wheat tested at the Nephi substation during the 5-year period from 1908 to 1912, ranked according to average actual yield.*

Rank.	C. I. No.	Variety.	Average stand (4 years).		Average date.		Height.	Average actual yield per acre.		Ratio of weight of grain to straw.	Average weight per bushel.
			Plants per acre.	Comparative.	Headed.	Ripe.		Grain.	Straw.		
			Thousands.	*Per cent.*	June.	July.	*In.*	*Bu.*	*Cwt.*		*Lbs.*
1	1437	Crimean	130	115	21	21	26	23.10	15.2	1:1.09	60.7
2	2998	Turkey	126	111	20	21	26	22.10	14.7	1:1.11	61.1
3	1442	Kharkof	133	118	21	21	26	21.86	14.1	1:1.07	61.2
4	1559	Crimean	126	111	21	20	26	21.59	14.1	1:1.08	61.1
	1355	Armavir	120	106	19	20	27		15.7	1:1.21	60.4
5	2048	Buigarian	107	95	21	21	27	21.46	14.3	1:1.11	60.3
6	1438	Ghirka	111	98	21	20	27	21.42	12.7	1:.99	60.9
7	1435	Crimean	126	111	20	21	29	21.15	12.6	1:1.00	59.8
8	1571	Turkey	126	111	20	19	26	21.13	13.8	1:1.09	60.9
9	2979	Alberta Red	110	97	20	20	25	21.07	14.0	1:1.11	61.1
10	1583	Kharkof	105	92	22	21	26	20.95	13.6	1:1.08	60.6
11	1787	Japanese	124	110	20	21	30	20.75	14.6	1:1.17	58.6
12	1436	Crimean	107	95	20	21	28	20.36	14.9	1:1.22	59.8
13	1563	Weissenberg	114	101	21	20	27	20.16	14.2	1:1.17	61.0
14	1562	Bacska	110	97	21	20	27	19.84	13.5	1:1.13	60.3
15	1756	Hard winter	114	101	20	21	27	19.56	12.9	1:1.10	60.0
16	1564	Pesterboden	110	97	21	21	27	19.39	13.3	1:1.14	60.0
17	2034	Hungarian	102	90	21	21	27	19.38	13.3	1:1.14	58.2
18	1656	Roumanian	108	96	20	22	26	19.30	12.5	1:1.08	59.7
19	1432	Crimean	111	98	21	21	26	18.86	15.1	1:1.33	60.4
20	1439	Ulta	119	105	21	23	25	18.85	12.9	1:1.14	60.9
21	2908	Malakof	96	85	21	22	25	18.63	11.8	1:1.06	60.7
22	1676	Servian	111	98	21	22	28	18.60	12.5	1:1.12	60.3
23	1783	Hard winter	111	98	21	22	26	18.57	11.6	1:1.04	61.2
24	1560	Banat	116	102	21	20	27	18.47	12.2	1:1.10	60.8
25	3055	Turkey	83	73	20	20	25	18.42	11.9	1:1.08	60.2
26	1532	Red Russian	111	98	21	23	26	17.74	11.7	1:1.10	60.5
27	2996	Gold Coin	98	87	20	23	27	17.33	11.5	1:1.11	59.4
Average			113	100	21	21	27	20.72	13.3	1:1.15	61.4

Comparative stand of winter wheats.—As used here, "stand" means the number of thousands of plants to the acre which have survived the winter and actually grown on the plats. This was determined in the following way: A light metal frame 3.3 feet square, containing 1/4,000 of an acre, was used to inclose the areas in which the plants were actually counted. On plats that had reasonably uniform stands, four areas, chosen at random but fairly representative of the entire plat, were selected and the plants in them counted. The total number of plants found on the four areas equaling 1/1,000 of an acre is the number of thousands of plants per acre. Where the plats were unusually lacking in uniformity, more than four areas were counted, and the number of plants per acre calculated accordingly.

There was found to be a wide variation in the average number of plants per acre for all varieties in different years. An exceptionally severe winter would result in considerable winterkilling (affecting some varieties more than others), and this invariably would result in low yields. There seems to have been no correlation, however, between the stand and the yield of the varieties. In many cases there would seem to be a direct relationship between stand and

yield, a thick stand resulting in a high yield, but in just as many cases a relatively thin stand would result in an equally high yield. In other cases a thick stand would be followed by a relatively low yield. These variations occurred each year and, as shown in Table X, the same facts are true in the averages of the four years. An explanation of this behavior probably lies in the fact that where the stand is thin the plants tiller more than they do when they are crowded in a thick stand. This point will be discussed more in detail in connection with the presentation of the observations made in the nursery tests.

In order to allow a more direct comparison of the stands of the winter-wheat varieties, the comparative stand is given in percentages in column 5 of Table X. It was computed in this manner: The total average number of plants per acre for all varieties (113,000) was used as 100 per cent. Then by dividing the number of thousands of plants per acre for any one variety by 113 the comparative stand of that variety was obtained.

Average date of heading.—The date on which any variety was fully headed was noted each year. The average date for the 5-year period was then determined. The comparative dates of heading for all varieties are presented in column 6 of Table X. It will be noted that there was little difference among varieties in this regard.

Average date of ripening.—When the kernels of any variety were in the hard dough stage it was considered ripe. The varieties were watched closely each year and the date of ripening was noted. The average dates for the 5-year period are given in column 7 of Table X. Here again it will be observed that little difference existed among the varieties. It appears that available soil moisture is the dominating factor in the control of cereal crops at Nephi and that all varietal differences are subsidiary to it when length of growing period is concerned. By July 1 the available soil moisture to a depth of 3.5 to 4 feet is sufficiently exhausted to check the growth and hasten maturity. Thus the varieties all ripen within a limit of a very few days.

Average height.—In each season the height of the crop was determined by taking the average of several measurements made in the plat. Each measurement was made from the ground to the tip of the heads, but not including the beards in bearded varieties.

The average height of the winter wheats at Nephi, as shown in Table X, is 27 inches. This is a low stature when compared with that of wheats grown in the more humid districts, and some difficulty is often experienced in harvesting the crops with a binder. The length of straw is not an important factor, however, where the header is used in harvesting, as it is almost exclusively on the dry farms in the Great Basin.

Ratio of grain to straw.—Table X shows the existence of a remarkably close ratio of grain to straw among the winter-wheat varieties at Nephi. In most cases only about a pound of straw was produced with each pound of grain. This ratio varied somewhat each year, depending upon the time of planting, amount of fall growth made, and the climatic conditions of the growing season. In 1908 the average ratio for all varieties was 1 to 1.21; in 1909 it was 1 to 1.03; in 1910 it was 1 to 1.25; in 1911, 1 to 1.01; and in 1912 it was 1 to 1.03.

Bushel weight.—The average bushel weight for all varieties of winter wheat grown at Nephi in 1908 was 59 pounds. In 1909 it was 56.6 pounds; in 1910 it was 59.8 pounds; in 1911 it was 62 pounds; and in 1912, 62.5 pounds. The average bushel weight of all varieties for the 5-year period, as shown in the last column of Table X, is 61.4 pounds, or 1.4 pounds above the standard weight. Each year the weights were determined after the grain had been cleaned.

Spring Wheats.

Previous publications[1] already have shown the superiority of winter wheats over spring wheats at Nephi, and it is generally understood that spring wheats are unprofitable in the Mountain States. For this reason spring wheats have occupied a minor position in the work of the Nephi substation. From 1904 to 1907, inclusive, only four varieties were tested. These were all durum varieties (Kahla, Adjini, Medeah, and Mohamed ben Bachir), and during that period the average yield obtained was 12.48 bushels per acre. In 1908 the Medeah variety was discarded and the Kubanka (C. I. 1440) variety was added. In the same year five varieties of common spring wheats were introduced. In 1910 all of the varieties were so nearly failures that the common spring wheats were discarded. Since the durum varieties showed less serious effects from the drought of 1910, they were continued, but were discarded at the close of the season of 1912. A summary of the yields obtained in the tests with spring wheats since 1908 is presented in Table XI.

[1] Jardine, W. M. Arid farming investigations. Utah Agricultural Experiment Station, Bulletin 100.
Farrell, F. D. Dry-land grains in the Great Basin. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 61, p. 10-11, 1910.

TABLE XI.—*Annual and average yields of four varieties of durum and five varieties of common spring wheat at the Nephi substation for five years, 1908 to 1912.*

C. I. No.	Variety.	Yield (bushels per acre).						
		1908	1909	1910	1911	1912	Average.	
							1908 to 1910	1908 to 1912
	DURUM WHEAT.							
1440	Kubanka	10.0	11.5	2.0	7.3	5.3	7.8	7.2
2088	Kahla	12.0	9.7	3.2	7.0	6.6	8.3	7.7
2087	Mohamed ben Bachir	8.0	8.8	2.2	6.0	6.3	6.3	6.3
1594	Adjini	12.5	7.8	2.2	5.5	4.1	7.5	6.4
	Average	10.6	9.5	2.4	6.5	5.6	7.5	6.9
	COMMON WHEAT.							
1517	Ghirka Spring	13.3	5.3	.2			6.3	
2398	Galgalos	12.0	9.7	.3			7.3	
3035	Mexican No. 1	22.7	8.7	.6			10.7	
3036	Mexican No. 2	12.7	11.7	1.0			8.5	
3056	New Zealand Spring	23.3	10.5	2.0			11.9	
	Average	16.8	9.2	.8			8.9	

In Table XI it is shown that the average yield of spring wheats for the past five years has been very low. In comparison with that of the winter wheats, which have average yields of 17 to 23 bushels per acre, the spring wheats have been very unprofitable. The durum varieties have yielded more uniformly from year to year than have the common varieties, but the average yield of the latter is a little in excess of that of the durums.

OATS.

Though wheat is by far the most important crop at Nephi, some work has been done with oat varieties. From the results obtained, no variety has proved to be financially profitable. Spring oats have suffered from the drought of summer, and winter oats have suffered from winterkilling. It is believed, however, that winter varieties will prove in the end to be the most profitable ones, because the climatic conditions in the Intermountain States are unfavorable for the growth of spring cereals in general.

WINTER OATS.

Only one variety of winter oats has been tested at the substation, viz, the Boswell Winter (C. I. No. 480), a black oat. Mr. Stephen Boswell, of Nephi, Utah, received a small quantity of seed of this oat from a friend in England who secured it from a sack marked "Seed oats," which stood on a wharf at Liverpool. Mr. Boswell planted the seed in his garden in the fall and was surprised to find that several plants survived the winter. The seed of these plants was saved and planted in the fall of that year. Again there was a

high percentage of winter survival among the plants. Then Mr. Boswell planted all the seed he had obtained from the second year's crop on his dry farm, which adjoins the substation on the south. He succeeded in getting a yield of 50 bushels to the acre in 1908 and since then he has obtained yields of from 25 to 40 bushels to the acre each year.

The yields obtained on the substation have not been so large as those on the Boswell farm. In 1907 the crop was planted on land that had produced a crop of wheat that year, and so much volunteer wheat grew that it was impossible to determine the oat yield in 1908. In 1909 the yield was 16 bushels per acre and in 1910 only 5.3 bushels. This low yield is difficult to understand, for on the Boswell farm and on some other farms in that vicinity where the oat was planted at approximately the same time a yield of about 25 bushels per acre was obtained. From the general appearance of the plat it was thought at the time that the drill had "missed" considerably at seeding time. This, however, was not known to have been the case. In 1911 a yield of 38.1 bushels per acre was obtained at the substation, while about 35 bushels per acre were obtained on the Boswell farm. The average yield at the substation during the period from 1909 to 1912 was 17.2 bushels per acre.

In the fall of 1911 a rate-of-seeding test and a date-of-seeding test with the Boswell Winter oat were begun. The highest yield obtained from these tests in 1912 was 19.8 bushels per acre; the lowest yield was 0.5 of a bushel. The average yield of eight plats in the tests was 9.2 bushels per acre. One other plat yielded 15 bushels per acre.

Although the Boswell Winter oat has not given very satisfactory yields on the substation, it is a promising variety. The rate, date, and depth of planting largely govern the yield, and these factors are being determined.

This variety has been sown extensively on farms in various parts of the West, and reports show varying degrees of success. In many localities it is believed that this oat will prove a success, while in other localities the results are not so promising. The color of the hull is objected to commercially, but the quality of the oat is very high and it is a valuable stock feed.

Spring Oats.

Seven varieties of spring oats have been tested. Three of these—the Sixty-Day, the Black American, and the Giant Yellow—have been grown since 1904. The Swedish Select and an improved strain of Sixty-Day were obtained from the Highmore substation in South Dakota in 1908. The former has been grown since that time, but the latter was discarded in 1909 because it was mixed with another variety. The Kherson variety was received from the Akron

(Colo.) substation in 1909 and was tested in the seasons of 1909, 1910, and 1911. In 1910 a variety known as the New Roosevelt was received from Mr. Erastus Madsen, Elsinore, Utah. This oat came from Wisconsin in 1908 and was grown one year under irrigation at Elsinore. It resembles the Swedish Select variety, though the berry is shorter and the glumes are whiter than those of the latter.

The average yields per acre of the Black American, Giant Yellow, and Sixty-Day varieties from 1904 to 1906, inclusive, were 31.7, 24.7, and 22.6 bushels, respectively.[1] The average acre yields of the same varieties for 1907 to 1909, inclusive, were 25.3, 19.5, and 20.9 bushels, respectively.[2]

A summary of the yields obtained from spring oats since 1908 is presented in Table XII.

TABLE XII.—*Annual and average yields obtained in varietal tests of spring oats at the Nephi substation, 1908 to 1912.*

C. I. No.	Variety.	Yield (bushels per acre).								
							Average.			
		1908	1909	1910	1911	1912	1908 to 1909	1909 to 1911	1910 to 1912	1908 to 1912
549	Black American	15.6	15.6	8.4	11.6	25.3	15.6	11.9	15.1	15.3
568	Giant Yellow	9.7	16.3	6.9	12.2	21.4	13.0	11.8	13.5	13.3
165	Sixty-Day (Nephi)	16.0	15.0	[1] 2.8	2.8	15.3	15.5	6.1	7.0	10.4
165	Sixty-Day (Highmore)	[2] 48.8	[3] 18.5	.....	.....	.....	33.6	.....	.....	.....
134	Swedish Select	[2] 44.1	[1] 15.4	[4] 6.2	8.8	24.1	28.3	10.1	13.0	19.7
459	Kherson	.....	16.6	0.6	5.9	.....	.....	7.7	.....	.....
	New Roosevelt	.....	.....	10.9	[3] 11.5	26.6	.....	.....	16.3	.....
	Average	26.8	16.2	5.9	8.8	22.5	21.2	9.5	13.0	14.7

[1] Average yield of 5 plats.
[2] Grown on land which had been fallow for two years. All the other varieties were grown in 1908 on plats which had produced wheat the previous season.
[3] Average yield of 3 plats.
[4] Average yield of 4 plats.

Table XII shows that the Black American, the Giant Yellow, and the Swedish Select varieties have yielded most satisfactorily since 1908. The Sixty-Day variety has given the lowest average yield and the Kherson oat also yielded low. The New Roosevelt oat has the highest average yield for the last three years. The average yields per acre for the varieties grown from 1909 to 1912, inclusive, are Black American, 15.2 bushels; Giant Yellow, 14.2 bushels; Swedish Select, 13.6 bushels; and Sixty-Day, 9 bushels. The average yield per acre for the Boswell Winter oat during the same period is 17.2 bushels, or 2 bushels higher than the Black American, which is the highest yielding spring variety. The yields are all low, and considerable work remains to be done before the oat crop is made a profitable one on the dry

[1] Jardine, W. M. Loc. cit.

[2] Farrell, F. D. Loc. cit.

lands of the Mountain States. It is interesting to note that the two best oat varieties are black, one a winter and the other a spring variety.

BARLEY.

During 1909 and 1910 two winter and three spring varieties of barley were included in the plat tests. Since 1910 the only barleys tested at Nephi have been winter varieties. Of these, two varieties have been included in the plat tests with winter cereals and four additional varieties have been included in the nursery tests. The results obtained from the two types (winter and spring) will be considered separately.

Winter Barley.

The test with winter barleys began in 1909. During 1909 and 1910 they gave a higher average yield than did the spring barleys for the same period, after which the latter were discarded. The inferiority of the spring barleys is due to poorer germination, lower tillering power, and later maturity. The winter barleys have ripened about 10 days earlier than the spring barleys and in that way have more fully escaped drought.

The best variety of winter barley tested has been the Utah Winter (C. I. No. 592), known also as White Club in some parts of the country. It is of the round or true 6-rowed type, and the head is short, very compact, and club shaped. The straw is very stiff and the heads are erect. The principal objection to the variety is the ease with which the heads are broken off when ripe. The seed of Utah Winter was obtained in 1908 from the Boswell farm, where it had yielded about 50 bushels per acre that year.

The other variety of winter barley included in the plat tests was Tennessee (C. I. No. 257). This is one of the square 6-rowed barleys often called 4-rowed. The head is longer and somewhat nodding and the straw is not so stiff as that of the Utah Winter. Otherwise their habits of growth are similar. They grow to a good height and their quality is excellent.

The annual and average acre yields of the two varieties are compared, together with a summary of the miscellaneous data which have been collected during the past four years, in Table XIII.

TABLE XIII.—*Annual and average yields of winter barley grown at the Nephi substation, 1909 to 1912, including summary of miscellaneous data.*

C. I. No.	Variety.	Average stand.		Average date.		Height.	Yield per acre.						Ratio of weight of grain to straw.	Average weight per bushel.
							Grain (bushels).					Straw (4-year average).		
		Plants per acre.	Comparative.	Headed.	Ripe.		1909	1910	1911	1912	Average.			
		M.	*P. ct.*	June	July	*In.*						*Cwt.*		*Lbs.*
592	Utah Winter	133	130	20	14	24	[1] 22.0	9.8	32.7	[2] 13.8	19.6	9.9	1:1.00	45
257	Tennessee Winter	89	80	22	21	24	18.1	16.5	24.6	4.1	15.8	6.4	1: .90	45
	Average	111	100	21	18	24	20.0	13.1	28.6	8.9	17.7	8.2	1: .95	45

[1] Average of 2 plats. [2] Average of 4 plats.

Table XIII shows that Utah Winter is the better of the two varieties in almost every instance. The average stand of this variety is considerably better than that of the Tennessee Winter, and it has ripened an average of one week earlier. The yield of the Utah Winter is noticeably better than that of the Tennessee Winter. The latter variety as a dry-land crop has a little advantage in ratio of grain to straw.

SPRING BARLEY.

Two varieties of spring barley, California and California Prolific, were grown for seven years at the substation previous to 1910. The average acre yield of these varieties for the years 1904 to 1906, inclusive,[1] was 24.3 and 22.4 bushels, respectively. One hooded hull-less variety was tested in addition to the two bearded varieties named above, in 1908, 1909, and 1910, after which they were discarded. Their annual and average yields for 1908 to 1910, inclusive, are presented in Table XIV.

TABLE XIV.—*Annual and average yields of spring barley grown at the Nephi substation for three years, 1908 to 1910.*

Variety.	Yield (bushels per acre).				
	1908	1909	1910	Average.	
				1908–1910	1909–1910
California	13.3	7.7	1.4	7.5	4.5
California Prolific	20.2	7.7	1.2	9.7	4.4
Hooded Hull-less	16.0	4.2	.....	6.7	2.1
Average	16.5	6.5	.9	8.0	3.7

[1] Jardine, W. M. Loc. cit.

As shown above, the average yields of the spring barleys for the last three years tested were very low. The yields for 1909 and 1910, when compared with those of the winter varieties for the same period, show the superiority of the winter type. Then, too, the spring varieties had a much shorter straw and for this reason were very difficult to harvest with the binder.

Fall-planted spring varieties.—Eleven varieties of spring barley, which had been grown several seasons as winter varieties at Arlington Farm, Virginia, by Mr. H. B. Derr, of the Office of Cereal Investigations, were planted at Nephi in the fall of 1911. The names and Cereal Investigation numbers of the varieties planted are as follows: Hybrid (648), Black Hull-less (618), Gatami (575), Pedigreed Chevalier (156), Orel (351), Hannchen (531), Hybrid (647), Bavarian (159), Princess (193), Hankau (197), and Turkestan (711). The Gatami, a black variety, gave the best yield, 5.7 bushels per acre. Some varieties were complete failures, while others ranged in yield per acre from 0.6 of a bushel to 4 bushels.

EMMER.

Extensive tests with emmer have been confined to winter varieties. Though spring varieties have been tested to some extent, they have not given as great promise of being successful as have the winter varieties. Of these, only one (Black Winter) has been tested in the plats. This one has received considerable attention, and the results of the tests are here reported.

Since 1908 Black Winter emmer (C. I. No. 2337) has been tested rather extensively at the substation. During that time it has exhibited a number of qualities which are desirable in dry-land grains. It has shown a good percentage of winter survival; it has headed and ripened uniformly; it has attained a good height; and it has yielded very satisfactorily. In every significant respect it has shown itself to be adapted to conditions at Nephi, and it is believed that this emmer will prove a valuable crop on the dry farms of the Mountain States.[1]

The average stand of Black Winter emmer at Nephi during the past five years is 121,000 plants per acre. The winter survival, which this stand represents, is considerably above the average for winter wheats. It has been a little later in heading and ripening than the winter wheats, but it has grown about 6 inches taller. In 1908 the yield per acre was 41.33 bushels; in 1909 it was 42.88 bushels (average of two plats); in 1910 it was 32 bushels; in 1911 it was 57.30 bushels; and in 1912 an average of five plats gave a yield of 25.50 bushels per acre. The grain, with kernels still inclosed in the glumes,

[1] Farmers' Bulletins 139 and 466 describe emmer and discuss its adaptation, characteristics, and value as a stock feed.

weighed 30 pounds per bushel. The ratio by weight of grain to straw was 1 to 0.83.

In the fall of 1911 the substation obtained several pounds of Buffum's Improved Black Winter emmer. Two adjacent half-acre plats were used to compare this strain with the ordinary strain of emmer, one plat of each being sown. Both plats received identical treatment before and after they were seeded. They were seeded on October 26 at the rate of 6 pecks per acre, using the "oats" side of the drill. It was noticed at the time of seeding that the kernel of Buffum's Improved was much softer than that of the ordinary strain. This may have been due to the fact that the Improved was produced on irrigated land. The glumes of the Improved were rather brown instead of black, as were those of the ordinary strain.

The winter survival was practically the same. The slight difference in number of plants per acre favored the ordinary strain. No difference was observed in the general appearance of the plats or in the color, vigor, or manner of growth of the plants. Both plats were in full head on July 5, and they were ripe on August 9 at an average height of 31 inches.

The ordinary strain, growing on the plat nearest the fence, was damaged to some extent by rabbits and ground squirrels. This fact may account for the slight difference in yield which favored the Improved.

The yield per acre of Buffum's Improved was 25.2 bushels; that of the ordinary strain was 22.1 bushels, a difference of 3.1 bushels per acre. As the latter strain had a slightly higher winter survival, it can be assumed that the damage done this plat by the rabbits and squirrels was responsible, in part at least, for the difference in yield.

It has been stated by Prof. Buffum [1] that the progenitors of the Improved Black Winter emmer were plants of "a different type, with large, coarse-growing straw and very large, composite heads which were different in appearance and of darker color than the ordinary ones." It was stated further in the same letter that since 1908 "it has come true to type," at Worland, Wyo. It is of particular interest to note that at Nephi not one composite head could be found among the plants which covered a total area of six-tenths of an acre. A few heads were light brown in color, but otherwise there was no perceptible difference between the Improved and the ordinary strains.

NURSERY EXPERIMENTS.

The nursery experiments at Nephi during 1908 to 1912, inclusive, afforded an opportunity for studying cereal varieties on a more intensive scale than was given by the plat experiments. Each test in the nursery was confined to short rows. The rows varied from

[1] Carleton, M. A. Winter emmer. U. S. Department of Agriculture, Farmers' Bulletin 466, 1912.

7 to 12 inches apart, according to the plan of each test. In most of the experiments the actual number of seeds planted in each row was known and these were placed at definite distances in the row. Under these conditions many accurate determinations were made and a great number of data of significance in a study of cereal varieties were noted.

The nursery experiments comprised three main groups: (1) Varietal tests (fig. 8) including small-grain head rows, increase rows, and minor cereals; (2) tests of the value of different sizes of seed; and (3) tests of different seed treatments for smut. The largest of the three groups was that containing the head rows. Of these there were 300 to 600 each year, while there were never more than 100

FIG. 8.—Winter cereal nursery at the Nephi substation in 1912. Looking west; summer fallow in the foreground; increase rows at left; head rows in center marked by white stakes; miscellaneous cereals at right. In the background is the low range separating Juab Valley from Dog Valley.

increase or miscellaneous rows. Each of the groups will be reviewed separately, and the data most pertinent at this time will be presented.

HEAD ROWS.

The head-row tests have been made to furnish pure-line selections of the cereal varieties under test at Nephi. In 1908 plants typical of each variety were selected from the plats of that year. Each plant was noted with respect to its height, number of culms and heads, uniformity of culm length, the average length of heads, average number of kernels to the head, seed-holding power, and the total weight of the grain. At least 2 heads of this typical plant were selected and used as parent heads in making the subsequent head-row sowings.

The length of these heads and the number of kernels each contained were determined. Finally 30 kernels from each head, except when the head contained fewer kernels, were planted in rows 10 feet long and 12 inches apart. The kernels were sown 4 inches apart in the row at the usual time, both in spring and fall. A furrow about 3 inches in depth was first opened with a wheel hoe. Then a board set with wooden pegs 4 inches apart was used to mark the places for the seeds. The seeds were placed by hand, one in each hole left by the pegs. The furrows were then covered with the wheel hoe and a rake. This left the seed from 3 to 4 inches beneath the surface of the ground. From then until the resulting plants were mature their behavior was observed and noted. Data pertaining to the following points were collected: Date of full emergence from the ground, percentage of survival, color, vigor, manner of growth, culms per plant, heads per plant, and height. Then what was believed to be the best plant growing under normal conditions in each row was selected for further propagation. The points considered in making these selections were: Vigor, uniformity of culms, number of heads, and length of heads. After the plant had been selected the remaining plants in the row were harvested and thrashed. The weight of their grain with that of the selected plant gave the total row yield. The mother plant selected was treated in the same manner as the parent plant of the previous year. This procedure has been repeated each year since 1908. During that time several selections of more recently introduced varieties have been added to the original number. The nursery at present contains selections of 95 varieties of winter cereals, including wheat, oats, barley, emmer, and spelt; and 23 varieties of spring cereals, including only oats and durum wheat. In only a few instances are there fewer than two selections of any one variety and in many instances there are more than two selections, sometimes as many as 20.

From such a large number of head rows, recorded as they are at Nephi, a great mass of data has been accumulated. Not all of these are germane to the purposes of this bulletin. Those which are of interest, however, in connection with the results obtained in the plat tests of the same varieties will be discussed here.

WINTER CEREAL HEAD ROWS.

An unexpectedly high percentage of winterkilling has occurred in the winter cereal head rows. The average winter survival has been about 65 per cent. This has varied, of course, with the severity of the winter conditions, and in that respect the rows were affected in practically the same proportion as were the plats.

The tillering of the plants has varied with the thickness of the stand. Where the stand was thick the plants have grown more erect

than where the stand was thin. When the plants were not crowded, the early growth of the culms was lateral and the plants would spread out over considerable space. Later, as the plants approached maturity, the position of the culms would be such as to give the row the appearance of having a much thicker stand than actually existed.

The average number of culms per plant seldom exceeded 25. Individual plants would sometimes have as many as 40 culms. This was true only where the plant occupied an isolated position in the row. These observations may aid in explaining the fact, previously noted in connection with the plat tests, that the number of plants to the acre is not a dependable criterion in estimating the yield of a cereal variety.

The average yields of the head rows give the varieties about the same rank as that which they occupied in the plat tests shown in the first part of Table VIII. The hard winter wheats were among the leading wheat varieties in the nursery, emphasizing more strongly their value as dry-land crops in the Mountain States.

SPRING CEREAL HEAD ROWS.

It was observed that the percentage of germination of the spring cereals generally was high. A much better stand was obtained in these than in the winter varieties, but the yields obtained were very low in comparison. This can be accounted for by the fact that the drought of the summer months has a very serious effect on the spring varieties, as previously noted in connection with the plat experiments. Then, too, though their percentage of germination was high, the spring varieties have a very low tillering power and seldom average more than five heads to the plant. Owing to the effect of the summer drought, the heads are short and the number of kernels per head is small.

Another observation made on spring varieties of cereals in the nursery is of interest. The plants were very poorly established in the soil. They apparently had a very limited root development, which often failed to support them during vigorous movements caused by exceptional gusts of wind. Frequently a number of plants in each row would be found completely uprooted and lying flat upon the ground.

INCREASE ROWS.

The bulk seed of the most promising head rows was planted in rows 121 feet long. These rows are known as "increase" rows, and are designed to increase the pedigreed seed from the head rows sufficiently for sowing plats where any improvement due to selection can be measured.

The rows were seeded with the drill used in seeding plats. Each cup of the drill was filled with the pure seed from a head-row selection.

In this way the seed was sown under what were approximately ordinary field conditions. About 60 to 70 winter selections and 15 to 45 spring selections were sown each year in increase rows. At the proper time they were harrowed in the same manner as all other cropped plats on the farm.

A study of the increase rows is important only in connection with the head rows. In most cases a decided improvement in the yielding power of the varieties was evident after they had gone through the processes of nursery selection. Whether this improvement was due to anything more than the production of pure strains has not been decided.

MINOR CEREALS.

A few short rows of several of the minor cereals have been grown to determine their adaptability to conditions at Nephi. Some work has been done with grain sorghums, broom corn, prosos, and millets. The results obtained give little promise that any of these crops will become profitable on the dry lands of the intermountain region. They seem not to be adapted to the altitude and climatic conditions obtaining in that region. They are very late getting started in the spring, and they are usually injured before ripening by the early frosts of autumn.

TESTS OF THE VALUE OF DIFFERENT SIZES OF SEED.

Experiments designed to determine the relative value of different sizes of seed wheat were begun in the spring of 1909 with two spring-wheat varieties. During the three succeeding years, 1910 to 1912, inclusive, two winter varieties were used.

The seed was separated by means of a series of screens into three sizes, (1) 3 mm. and larger, (2) 2 to 2.5 mm., and (3) less than 2 mm. In addition to these three sizes of seed ordinary bulk seed of each of the varieties was used, making four lots in all. The seed was sown in rows 5 feet long and 8 inches apart. Eighteen rows of each lot of seed were sown, 3 rows being sown at each of the following rates: 2, 4, 6, 8, 10, and 12 inches apart in the row. The seed was placed about 2 inches deep in the rows. A guard row was sown around each group of 18 rows. There were thus four groups of each variety or eight groups in all. They appeared in the field as illustrated in figure 9.

Seeding was done at the usual time and in the following manner: A furrow about 2 to 3 inches deep was opened for each row. The seeds were dropped at the desired distances in the row and then covered. Stakes which were numbered to correspond with the record numbers were placed at the head of each row. As early as possible the next summer, usually about June 1, a count was made of the number of plants growing in each row. The percentage of

winter survival was then determined by dividing the number of plants growing by the number of seeds planted.

The number of plants maturing was determined also. This number seldom differed from the number of plants surviving. Occasionally, however, a weak plant would fail to mature. For this reason it was necessary to make the second count. If the second count were not made, the possibility of error would be enhanced when the average number of heads to the plant was being determined.

Harvesting was done by hand. The heads of each row were picked and placed in a paper bag. Later, in the laboratory, the average length in inches of the heads of all the plants in each row was determined. No differences less than a quarter of an inch were noted in making head measurements. The heads were then thrashed by means of a small hand thrasher made especially for small row work. In this manner the row yields were obtained with reasonable accuracy.

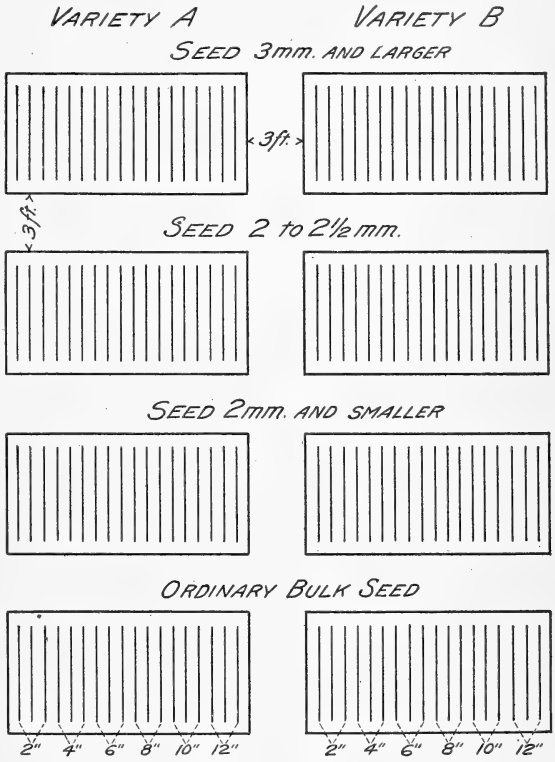

FIG. 9.—Plat arrangement for testing different sizes of seed of two varieties of winter wheat, at six different rates of seeding.

SPRING WHEAT VARIETIES.

The test of the value of the different sizes of seed of spring wheat, as stated before, was conducted during only one season, in 1909. Two varieties were used, one durum, Kubanka (C. I. No. 1440), and one common, Spring Ghirka (C. I. No. 1517). The durum variety, Kubanka, has light-brown or yellowish chaff and beards and large, hard, clear-amber kernels. The common variety, Spring Ghirka, is beardless, and it has a white chaff and medium-sized, hard, red kernels. Some difficulty was experienced in obtaining the desired

sizes of seed of these varieties. It was as difficult to get a sufficient number of the small-sized Kubanka kernels as it was to get the large-sized Ghirka kernels. The different grades of seeds were obtained, however, and sown as described. A summary of the results obtained is presented in Table XV.

Data relative to percentage of survival, number of plants maturing, number of heads per plant, and yield in grams are presented. The figures in each column of the table represent the average of three rows. For example, the first figure in the first column, 61, represents the average percentage of survival of large seed of Kubanka sown 2 inches apart in three rows which were 5 feet long and 8 inches apart. Averages of all rates of seeding for each size of seed are given, as well as averages of all sizes of seed for each rate of seeding.

TABLE XV.—*Results obtained from sowing large, medium, small, and unseparated seed of two varieties of spring wheat, at different distances in the row, at the Nephi substation in 1909.*

Variety and size of seeds.	Percentage of survival.							Number of plants maturing.							Number of heads per plant.							Yield of rows (grams).						
	Distance between seeds (inches).						Average.	Distance between seeds (inches).						Average.	Distance between seeds (inches).						Average.	Distance between seeds (inches).						Average.
	2	4	6	8	10	12		2	4	6	8	10	12		2	4	6	8	10	12		2	4	6	8	10	12	
Kubanka (C. I. No. 1440):																												
Large (3 mm. and larger)	61	69	64	67	57	67	64	19	11	7	6	4	4	9	2	2	3	5	4	4	3	42	33	31	36	25	24	32
Medium (2 to 2.5 mm.)	58	69	45	44	43	33	49	18	11	5	4	3	2	7	2	2	4	5	6	4	4	32	29	21	24	32	14	25
Small (less than 2 mm.)	26	25	36	33	29	33	30	8	4	2	3	2	2	4	3	5	5	3	4	4	4	30	22	18	12	16	11	18
Unseparated	45	50	54	55	57	67	55	14	8	6	5	4	4	7	3	4	5	5	5	6	5	42	36	38	26	27	29	33
Average	48	53	50	50	46	50	50	15	9	5	5	3	3	7	3	3	4	5	5	5	4	37	30	27	24	25	20	27
Ghirka (C. I. No. 1517):																												
Large (3 mm. and larger)	68	69	73	78	86	83	76	21	11	8	7	6	5	9	3	5	6	6	7	6	5	48	38	37	39	42	30	39
Medium (2 to 2.5 mm.)	61	56	64	67	71	50	61	19	9	7	6	5	3	8	3	5	6	7	8	9	6	50	33	39	34	28	28	35
Small (less than 2 mm.)	55	62	36	44	57	33	48	17	10	4	4	4	2	7	4	5	9	8	7	6	7	44	38	31	24	20	12	28
Unseparated	61	56	45	44	43	50	50	19	9	5	4	3	3	7	4	6	7	7	8	9	7	56	43	39	28	23	23	35
Average	61	61	55	58	64	54	57	19	10	6	5	4	3	8	4	5	7	7	8	8	6	50	38	37	31	28	23	34

Table XV shows that the large seed of both varieties had the highest percentage of survival in every instance. The small seed had the lowest percentage of survival in most instances, while the average survival of the original, unseparated seed was generally high. The large seed produced the greatest number of plants which matured. Fewer heads per plant, however, were produced by the large seed than by any other grade. The yields obtained from the large seed were higher, in most cases, than were those obtained from the medium or small seed. There was little difference, however, between the yields obtained from the large and the original, unseparated seed.

It is of interest to note that the thickest seedings resulted in the highest yields in all cases; also, that the common variety was generally better than the durum variety.

WINTER-WHEAT VARIETIES.

The two varieties of winter wheat used for tests during 1910 to 1912, inclusive, were Koffoid (C. I. No. 2997) and Turkey (C. I. No. 2998). The Koffoid variety is beardless, with light-brown chaff and large, soft, white kernels. The Turkey variety is bearded, with white chaff and medium, hard, red kernels. Some difficulty was experienced in grading these varieties, as was the case with the spring wheats. A summary of the results obtained is presented in Table XVI. The essential difference between this table and the preceding one is that this is a summary of three years while the other was a summary of but one. The average length of heads, also, has been added in Table XVI. The figures for each year represent an average of three rows. The averages, then, represent an average of three rows for three years. In the right-hand column are given for each size of seed the average results for all rates of seeding for three years. A summary of the averages presented in the table is also given, which will facilitate the making of comparisons.

Table XVI shows that the percentage of survival from the different sizes of seed varied widely during the 3-year test. The relative value of the different grades would change each year if based on percentage of winter survival. This behavior resulted in averages which showed no great differences. The medium-sized seed of the Koffoid variety gave the highest average, while with the Turkey the small seed gave the highest average. The original unseparated seed of the Koffoid was low in percentage of survival, while that of the Turkey was high. The large seed of both varieties gave a relatively low percentage of survival. In average number of plants maturing, the relative value of the different grades was about the same as in percentage of survival.

In average number of heads per plant the large seed showed the greatest value. In this respect the large seed of both varieties led in almost every instance. The small seed and the original bulk seed were practically equal in average number of heads produced per plant, and both grades were lower in average than the medium size of seed. The rate of seeding was an effective factor in determining the number of heads per plant. This was lowest where the plants were 2 inches apart in the row. Between the 2-inch and the 6-inch rates of seeding there was a gradual increase in the number of heads per plant. But after the 6-inch rate the number of heads per plant remained about the same for all subsequent rates. From this it seems that the 6-inch rate allows sufficient space in the row for winter wheat to reach its greatest efficiency in tillering.

TABLE XVI.—*Average results obtained from sowing large, medium, small, and unseparated seed of two varieties of winter wheat at different distances in the row at the Nephi substation, for three years, 1910 to 1912.*

Variety and descriptive data.	Detailed results.																								Summary of results.						
	Seeds 2 inches apart in row.				Seeds 4 inches apart in row.				Seeds 6 inches apart in row.				Seeds 8 inches apart in row.				Seeds 10 inches apart in row.				Seeds 12 inches apart in row.				Average of all rates.	Distance between seeds (inches).						
	1910	1911	1912	Average.	1910	1911	1912	Average.	1910	1911	1912	Average.	1910	1911	1912	Average.	1910	1911	1912	Average.	1910	1911	1912	Average.		2	4	6	8	10	12	Average.
KOFFOID (C. I. No. 2997).																															
Percentage of survival:																															
Large (3 mm. or larger)	45	41	72	53	44	65	71	60	55	52	85	64	45	37	63	48	43	62	62	56	33	61	72	55	56	53	60	64	48	56	55	56
Medium (2 to 2.5 mm)	42	73	60	58	44	94	54	64	27	85	48	53	35	89	74	66	28	90	91	70	33	94	83	70	64	58	64	53	66	70	70	64
Small (less than 2 mm.)	32	76	63	57	44	77	50	57	36	76	60	57	23	89	33	48	43	90	43	59	50	72	50	57	56	57	57	57	48	59	57	56
Unseparated	26	81	34	47	44	85	29	53	45	85	26	52	35	70	4	36	28	95	19	47	33	94	44	57	49	47	53	52	36	47	57	49
Average																										54	58	56	49	56	60	56
Number of plants maturing:																															
Large (3 mm. or larger)	14	13	22	16	7	10	11	9	6	6	9	7	4	3	6	4	3	4	4	4	2	4	4	3	7	16	9	7	4	4	3	7
Medium (2 to 2.5 mm.)	13	23	19	18	7	15	9	10	3	9	5	6	3	8	7	6	2	6	6	5	2	6	5	4	8	18	10	6	6	5	4	8
Small (less than 2 mm.)	10	24	20	18	7	12	8	9	4	8	7	6	2	8	3	4	3	6	3	4	3	4	3	3	7	18	9	6	4	4	3	7
Unseparated	8	25	11	15	7	14	5	9	5	9	3	6	3	7	1	4	2	7	1	3	2	6	3	4	7	15	9	6	4	3	4	7
Average																										17	9	6	4	4	3	7
Number of heads per plant:																															
Large (3 mm. or larger)	5	8	4	6	7	10	5	7	7	12	7	9	9	17	7	11	9	18	7	11	11	12	8	10	9	6	7	9	11	11	10	9
Medium (2 to 2.5 mm.)	5	4	3	4	6	5	6	6	9	8	8	8	9	8	8	8	5	12	6	8	7	9	7	8	7	4	6	8	8	8	8	7
Small (less than 2 mm.)	5	5	4	5	6	7	5	6	6	9	12	9	5	8	3	5	5	8	6	6	5	8	2	5	6	5	6	9	5	6	5	6
Unseparated	6	4	4	5	6	5	6	6	8	5	5	6	8	8	5	7	6	8	5	6	8	8	8	8	6	5	6	6	7	6	8	6
Average																										5	6	8	8	8	8	7
Length of heads (inches):																															
Large (3 mm. or larger)	2.6	2.5	2.6	2.6	3.2	2.4	2.7	2.8	3.1	2.5	2.8	2.8	3.1	2.3	2.9	2.8	3.1	2.5	2.8	2.8	3.3	2.4	2.8	2.8	2.8	2.6	2.8	2.8	2.8	2.8	2.8	2.8
Medium (2 to 2.5 mm.)	3.0	2.5	2.7	2.7	3.2	2.4	2.7	2.8	3.2	2.5	2.8	2.8	3.2	2.7	2.8	2.9	3.0	2.7	2.6	2.8	2.8	3.4	2.5	2.9	2.8	2.7	2.8	2.8	2.9	2.8	2.9	2.8
Small (less than 2 mm.)	2.9	2.4	2.6	2.6	3.1	2.5	2.6	2.7	3.2	2.7	2.5	2.8	3.0	2.4	2.7	2.7	3.2	2.5	3.0	2.9	2.9	2.6	2.4	2.6	2.7	2.6	2.7	2.8	2.7	2.9	2.6	2.7
Unseparated	3.0	2.5	2.8	2.8	3.0	2.5	2.7	2.7	3.2	2.6	2.6	2.8	3.1	2.6	3.2	3.0	3.1	2.6	2.6	2.8	3.0	2.4	3.1	2.8	2.8	2.8	2.7	2.8	3.0	2.8	2.8	2.8
Average																										2.7	2.7	2.8	2.8	2.8	2.8	2.8

Yield per row (grams):																															
Large (3 mm. or larger)	56	47	78	60	47	34	51	44	37	21	60	39	35	19	37	30	17	27	36	27	23	15	44	27	38	60	44	39	30	27	27	38
Medium (2 to 2.5 mm.)	54	49	51	51	43	29	40	37	25	20	33	26	27	18	51	32	9	27	33	23	17	19	37	24	32	51	37	26	32	23	24	32
Small (less than 2 mm.)	36	54	63	51	32	40	40	37	33	31	49	38	10	36	11	19	10	22	20	17	14	14	6	11	29	51	37	38	19	17	11	29
Unseparated	45	67	43	52	39	45	29	38	37	35	14	29	28	28	6	21	11	24	13	16	13	17	20	17	29	52	38	29	21	16	17	29
Average																										53	39	33	25	21	20	32
TURKEY (C. I. No. 2998).																																
Percentage of survival:																																
Large (3 mm. or larger)	74	42	66	61	87	42	68	66	73	43	58	58	67	41	60	56	71	38	48	52	67	17	33	39	55	61	66	58	56	52	39	55
Medium (2 to 2.5 mm.)	71	40	60	57	87	33	63	61	82	40	45	56	78	30	56	55	86	48	76	70	67	44	50	54	59	57	61	56	55	70	54	59
Small (less than 2 mm.)	61	67	48	59	87	81	66	78	73	76	66	72	67	89	63	73	71	76	47	65	67	78	22	56	67	59	78	72	73	65	56	67
Unseparated	74	74	52	67	62	92	36	63	63	76	70	70	67	85	59	70	100	81	29	70	67	89	17	58	66	67	63	70	70	70	58	66
Average																										61	67	64	63	64	52	62
Number of plants maturing:																																
Large (3 mm. or larger)	23	13	21	19	14	6	11	9	8	4	7	6	6	4	5	5	5	3	3	4	4	1	2	2	7	19	9	6	5	4	2	7
Medium (2 to 2.5 mm.)	22	12	19	18	14	5	10	10	9	4	5	6	7	3	5	5	6	3	5	4	4	3	3	3	8	18	10	6	5	4	3	8
Small (less than 2 mm.)	19	21	15	18	14	13	11	13	8	8	7	8	6	8	3	6	5	5	3	4	4	5	1	3	9	18	13	8	6	4	3	9
Unseparated	23	23	16	21	10	15	6	10	7	8	8	8	6	8	5	6	7	6	2	5	4	5	1	3	9	21	10	8	6	5	3	9
Average																										19	10	7	5	4	3	8
Number of heads per plant:																																
Large (3 mm. or larger)	6	9	5	7	7	13	6	9	10	14	8	11	12	15	6	11	16	18	3	12	10	6	4	7	10	7	9	11	11	12	7	10
Medium (2 to 2.5 mm.)	5	11	5	7	6	14	4	8	8	17	6	10	9	12	9	10	11	12	6	10	11	12	8	10	9	7	8	10	10	10	10	9
Small (less than 2 mm.)	6	6	4	5	6	8	4	6	8	10	7	8	7	12	6	8	5	14	4	8	7	9	16	11	8	5	6	8	8	8	11	8
Unseparated	5	7	5	6	7	9	5	7	9	10	5	8	11	12	6	10	9	13	8	10	13	8	3	8	8	6	7	8	10	10	8	8
Average																										6	7	9	10	10	9	9
Length of heads:																																
Large (3 mm. or larger)	2.8	2.2	2.2	2.4	2.5	2.4	2.5	2.5	2.5	2.7	2.5	2.6	2.8	2.4	2.6	2.6	2.5	2.6	2.3	2.5	2.7	1.5	2.6	2.3	2.5	2.4	2.5	2.6	2.6	2.5	2.3	2.5
Medium (2 to 2.5 mm.)	2.5	1.9	2.1	2.2	2.5	2.5	2.3	2.4	2.6	2.7	2.4	2.6	2.6	2.0	2.5	2.4	2.7	2.4	2.4	2.5	2.7	2.5	2.5	2.6	2.4	2.2	2.4	2.6	2.4	2.5	2.6	2.4
Small (less than 2 mm.)	2.3	2.1	2.2	2.2	2.3	2.0	2.2	2.2	2.4	2.4	2.3	2.4	2.5	2.2	2.2	2.3	2.6	2.2	2.2	2.3	2.6	2.1	2.6	2.4	2.3	2.2	2.2	2.4	2.3	2.3	2.4	2.3
Unseparated	2.6	1.9	2.4	2.3	2.4	2.2	2.3	2.3	2.5	2.6	2.3	2.5	2.4	2.3	2.4	2.4	2.5	2.3	2.1	2.3	2.6	2.2	2.0	2.3	2.4	2.3	2.3	2.5	2.4	2.3	2.3	2.4
Average																										2.3	2.3	2.5	2.4	2.4	2.4	2.4
Yield per row (grams):																																
Large (3 mm. or larger)	75	53	63	64	56	45	45	49	57	30	39	42	45	29	33	36	59	25	20	35	30	3	15	16	40	64	49	42	36	35	16	40
Medium (2 to 2.5 mm.)	60	67	52	60	45	42	30	39	50	44	29	41	38	18	37	31	43	21	23	29	34	24	21	26	38	60	39	41	31	29	26	38
Small (less than 2 mm.)	56	51	39	49	42	52	32	42	35	44	41	40	30	41	24	32	16	34	10	20	16	19	19	18	33	49	42	40	32	20	18	33
Unseparated	61	79	45	62	43	65	23	44	40	53	29	41	38	48	25	37	43	43	12	33	33	24	15	24	40	62	44	41	37	33	24	40
Average																										59	43	41	34	29	21	38

TABLE XVI. *Average results obtained from sowing large, medium, small, and unseparated seed of two varieties of winter wheat at different distances in the row at the Nephi substation, for three years, 1910 to 1912*—Continued.

GENERAL SUMMARY OF AVERAGES.

Statement of averages.	Percentage of survival.							Number of plants maturing.							Number of heads per plant.							Length of heads (inches).							Yield per row (grams).						
	Distance between seeds (inches).						Average.	Distance between seeds (inches).						Average.	Distance between seeds (inches).						Average.	Distance between seeds (inches).						Average.	Distance between seeds (inches).						Average.
	2	4	6	8	10	12		2	4	6	8	10	12		2	4	6	8	10	12		2	4	6	8	10	12		2	4	6	8	10	12	
Average for Koffoid	54	58	56	49	58	60	56	17	9	6	4	4	3	7	5	6	8	8	8	8	7	2.7	2.7	2.8	2.8	2.8	2.8	2.8	53	39	33	25	21	20	32
Average for Turkey	61	67	64	63	64	52	62	19	10	7	5	4	3	8	6	7	9	10	10	9	9	2.3	2.3	2.5	2.4	2.4	2.4	2.4	59	43	41	34	29	21	38
Average for both varieties	58	63	60	56	61	56	59	18	9	6	4	4	3	7	5	6	8	9	9	8	8	2.5	2.5	2.6	2.6	2.6	2.6	2.6	56	41	37	29	25	20	35

A remarkable uniformity is observed in the length of heads from all sizes of seed sown at all the different rates.

In yield the large seed gave the best results. This was true quite generally throughout the test. With all sizes of seed the 2-inch rate of seeding gave the highest yields. This evidently was due to the facts that (1) the percentage of survival from the 2-inch spacing was equal to that from the other rates, thus leaving more plants in the row, and (2) though the number of heads per plant was smaller there was no great difference in the average length of the heads.

The general summary of Table XVI shows further that with one exception the Turkey variety surpassed the Koffoid variety on every point. Only in the case of the length of the head the Koffoid variety had the advantage. But what the Turkey variety lacked in length of head it made up in percentage of survival, in number of heads per plant, and hence in yield.

TREATMENT OF SEED WHEAT FOR BUNT.

Tests comprising 76 nursery rows, each 2 rods long, for the purpose of studying the effects of various seed treatments on bunt infection, were started in the fall of 1909 and continued through 1912. The plan of the experiment was made by Mr. Edward C. Johnson, then pathologist in charge of cereal-disease work.

The object of the experiment was to determine the effect on bunt infection of (1) the time of planting winter wheat, (2) treatment of the seed with different solutions of varying strength, and (3) the removal of smut balls during seed treatment. The last two points, being closely related, were studied simultaneously.

Two varieties of winter wheat were used, viz, Turkey (C. I. No. 2998) and Odessa (C. I. No. 3274). The Turkey is a bearded, white-chaffed, hard, red-grained variety, while Odessa is a beardless, brown-chaffed, soft, red-grained variety. Both varieties were heavily inoculated with smut spores taken from the Odessa wheat grown on the farm.

TIME OF SEEDING AS AFFECTING BUNT INFECTION.

Seed of each variety, which previously had been inoculated, was sown without treatment on six different dates in 1910 and 1912. In 1911 this part of the test was omitted. One 2-rod row of each variety was sown on each of the following dates: August 15, September 1, September 15, October 1, October 15, and November 1. The seed was sown by hand and at a much higher rate than that at which a machine would have sown it.

When the grain was ripening the next fall, the percentage of bunt in each row was determined by the following method. At least 200

heads were counted in the center of each row, which was considered typical of the entire row. Then the number of bunted heads found among the 200 previously counted was noted and the percentage of bunt determined. The data obtained are given in Table XVII.

TABLE XVII.—*Percentages of bunt infection noted in a time-of-seeding test with two varieties of winter wheat at the Nephi substation in 1910 and 1912.*

[The seed had been inoculated with bunt spores.]

Variety.	Date of planting.											
	Aug. 15.		Sept. 1.		Sept. 15.		Oct. 1.		Oct. 15.		Nov. 1.	
	1910	1912	1910	1912	1910	1912	1910	1912	1910	1912	1910	1912
Turkey	0	50	0	42	5	33	20	39	35	19	35	2
Odessa	0	43	5	49	25	19	12	2	15	1	18	3
Average	0	46	2	46	15	26	16	20	25	10	26	2

There is so much discrepancy in the results obtained that no relation is indicated between the time of sowing winter wheat and bunt infection. The results of the first year strongly favored early planting, while those of the second year favored late planting. The results, as a whole, seem only to emphasize the necessity of seed treatment for bunt infection.

COPPER-SULPHATE AND FORMALIN TREATMENTS.

Thoroughly inoculated seed of each variety was used in studying the effect of copper sulphate and formalin on bunt. An outline of the various treatments tested is given below:

Copper-sulphate treatment:

(*a*) 1 pound of copper sulphate to 5 gallons of water; seed soaked 10 minutes in this solution and then dried.

(*b*) 1 pound of copper sulphate to 5 gallons of water; seed soaked 10 minutes in this solution and then soaked 10 minutes in a solution of lime and dried.

(*c*) 1 pound of copper sulphate to 10 gallons of water; seed soaked 10 minutes and dried.

(*d*) 1 pound of copper sulphate to 10 gallons of water; seed soaked 10 minutes and treated with lime as in *b*.

(*e*) 3 pounds of copper sulphate to 10 gallons of water; seed soaked 10 minutes and dried.

(*f*) 3 pounds of copper sulphate to 10 gallons of water; seed soaked 10 minutes and treated with lime as in *b*.

Formalin treatment:

(*a*) 5 parts of formalin to 1,000 parts of water; seed soaked 10 minutes and dried.
(*b*) 5 parts of formalin to 1,000 parts of water; seed soaked 10 minutes and kept moist 2 hours.
(*c*) 2.5 parts of formalin to 1,000 parts of water; seed soaked 10 minutes and dried.
(*d*) 2.5 parts of formalin to 1,000 parts of water; seed soaked 10 minutes and left moist 2 hours.
(*e*) 1.25 parts of formalin to 1,000 parts of water; seed soaked 10 minutes and dried.
(*f*) 1.25 parts of formalin to 1,000 parts of water; seed soaked 10 minutes and kept moist 2 hours.

Commercial formalin, a 40 per cent solution of formaldehyde, was used.

The treatments with both copper sulphate and formalin were applied to seed of the two varieties in two ways—(1) with the smut balls left in, as is ordinarily the case in farm practice, and (2) with the smut balls removed. This was accomplished by immersing the seed in water, and skimming off the smut balls as they rose to the surface. Thus, two rows of each variety were treated in the same manner, except that the smut balls had been removed from the seed used for one row and not from the other.

One hundred and fifty seeds were sown in each row. The rows were 2 rods long and the seeds were sown at equal distances apart in the row. Besides the rows of treated seed, there were sown check rows which had been neither inoculated nor treated and control rows which had been inoculated but not treated.

The seeding was done by hand and in the manner previously described for the nursery sowings. In the fall of 1909 and again in 1911, when the 1910 and 1912 rows were being sown, care was taken to disinfect the hands after each row was planted. This precaution was not taken in the fall of 1910 when the 1911 rows were being sown. The failure to take this precaution may explain the discrepancies appearing in the results of 1911. The details of the entire test and their summary are given in Table XVIII. The percentage of smut was determined in the same manner as that in the time-of-seeding test.

The results presented in Table XVIII show the effectiveness of all treatments when the treated rows are compared with the controls. The third treatment with copper sulphate (1 pound to 10 gallons of water, soaked 10 minutes and dried) gave the best results of any treatments with that compound. The fourth treatment with formalin (2.5 to 1,000 parts, soaked 10 minutes and kept moist 2 hours) gave the best results of any of the formalin treatments. Results obtained with these two treatments were almost identical, but the ease with which formalin can be handled gives that treatment an advantage over the copper-sulphate treatment.

TABLE XVIII.—*Results obtained from treating two varieties of winter wheat with various solutions of copper sulphate and formalin at the Nephi substation in three years, 1910 to 1912.*

Nature of treatment.	Detailed results (per cent).																								Summary of results (per cent).							
	Smut balls removed.												Smut balls not removed.												Smutted heads.				Winter survival.			
	Odessa (C. I. 3274).						Turkey (C. I. 2998).						Odessa (C. I. 3274).				Turkey (C. I. 2998).				Odessa.		Turkey.		Odessa.		Turkey.	
	Smutted heads.				Winter survival.				Smutted heads.				Winter survival.				Smutted heads.				Winter survival.											
	1910	1911	1912	Average.	1910	1911	1912	Average.	1910	1911	1912	Average.	1910	1911	1912	Average.	1910	1911	1912	Average.	1910	1911	1912	Average.	Smut balls removed.	Smut balls not removed.	Smut balls removed.	Smut balls not removed.	Smut balls removed.	Smut balls not removed.	Smut balls removed.	Smut balls not removed.
COPPER SULPHATE.																																
Check: Turkey (C. I. 2998), neither inoculated nor treated	..	0	0	0	..	41	24	33	..	0	0	0	..	46	15	30	..	7	0	3	..	43	20	31	..	0	0	0	..	47	19	33	0	3	0	0	33	31	30	33 46
Control, inoculated but not treated	6	10	21	12	49	29	23	33	12	23	4	13	90	41	15	49	15	50	7	24	48	32	16	32	15	39	15	23	80	37	21	46	12	24	13	23	33	32	49	
(*a*) 1 pound $CuSo_4$ to 5 gallons H_2O, soaked 10 minutes and dried	0	1	0	0	42	25	9	25	0	0	0	0	76	57	19	51	3	0	0	1	24	16	15	18	0	0	3	1	88	23	20	44	0	1	0	1	25	18	51	44
(*b*) Same as *a*, then soaked 10 minutes in CaO solution and dried	0	0	3	1	50	27	26	34	0	6	0	2	78	53	20	50	2	1	0	1	42	26	17	28	11	0	0	4	93	36	21	50	1	1	2	4	34	28	50	50
(*c*) 1 pound $CuSo_4$ to 10 gallons H_2O, soaked 10 minutes and dried	0	0	0	0	56	32	25	38	0	0	0	0	79	57	16	51	0	3	0	1	38	25	25	29	0	0	0	0	87	33	21	47	0	1	0	0	38	29	51	47
(*d*) Same as *c* plus CaO as in *b*	0	3	0	1	54	37	32	41	0	0	0	0	80	57	13	50	6	5	0	4	56	30	30	39	12	0	0	4	84	33	25	47	1	4	0	4	41	39	50	47
(*e*) 3 pounds $CuSo_4$ to 10 gallons H_2O, soaked 10 minutes and dried	0	6	0	2	33	35	13	27	0	0	0	0	68	54	8	43	0	13	0	4	28	18	5	17	0	0	0	0	82	12	19	38	2	4	0	0	27	17	43	38
(*f*) Same as *e* plus CaO as in *b*	1	11	0	4	44	33	29	35	0	0	0	0	82	63	15	53	4	0	0	1	31	28	13	24	6	0	0	2	88	39	20	49	4	1	0	2	35	24	53	49
Check: Turkey (C. I. 2998), neither inoculated nor treated	..	0	0	0	..	45	28	34	..	5	..	..	2	..	37	22	30	..	6	0	2	..	42	19	30	..	4	0	1	..	44	18	31	0	2	2	1	34	30	30	31
Control, inoculated but not treated	2	45	14	21	44	40	20	35	5	35	14	18	74	53	19	49	13	36	5	15	48	41	18	36	13	9	3	9	88	45	11	48	21	15	18	9	35	36	49	48
FORMALIN.																																
Check: Turkey (C. I. 2998), neither inoculated nor treated	..	0	0	0	..	45	28	36	..	5	0	2	..	37	22	30	..	6	0	3	..	42	19	30	..	4	0	2	..	44	18	31	0	3	2	2	36	30	30	31
Control, inoculated but not treated	5	45	14	21	42	40	20	34	5	35	14	18	77	53	19	50	5	36	5	15	54	41	18	38	18	9	3	10	84	45	11	47	21	15	18	10	34	38	50	47
(*a*) 5 parts formalin to 1,000 parts H_2O, soaked 10 minutes and dried	1	0	0	0	25	27	27	26	0	1	0	0	70	56	16	47	0	0	0	0	15	15	8	13	0	0	0	0	64	29	7	33	0	0	0	0	26	13	47	33
(*b*) 5 parts formalin to 1,000 parts H_2O, soaked 10 minutes, kept moist 2 hours	0	5	0	1	36	33	14	28	0	0	0	0	77	62	9	49	0	0	0	0	33	29	11	24	0	4	0	1	71	37	5	38	1	0	0	1	28	24	49	38
(*c*) 2½ parts formalin to 1,000 parts H_2O, soaked 10 minutes and dried	0	7	0	2	55	29	18	34	0	0	0	0	78	37	18	44	0	0	0	0	48	31	16	32	0	0	0	0	74	38	5	39	2	0	0	0	34	32	44	39

(*d*) $2\frac{1}{2}$ parts formalin to 1,000 parts H_2O, soaked 10 minutes, kept moist 2 hours	0	0	0	0	58	40	30	43	0	0	0	0	88	43	17	49	0	3	0	1	67	40	18	42	0	0	0	0	80	42	14	45	0	1	0	0	43	42	49	45
(*e*) $1\frac{1}{4}$ parts formalin to 1,000 parts H_2O, soaked 10 minutes and dried	0	6	0	2	53	33	35	40	0	7	0	2	84	43	13	47	0	0	0	0	56	46	24	42	0	0	0	0	88	41	21	50	2	0	2	0	40	42	47	50
(*f*) $1\frac{1}{4}$ parts formalin to 1,000 parts H_2O, soaked 10 minutes, kept moist 2 hours	0	3	0	1	63	34	39	45	0	3	0	1	84	43	17	48	0	2	0	1	54	43	19	39	0	0	0	0	86	37	19	47	1	1	1	0	45	39	48	47
Check: Turkey (C. I. 2998), neither inoculated nor treated	..	7	0	3	..	43	20	31	..	0	0	0	..	47	19	33	..	0	0	0	..	46	15	30	..	7	0	3	..	55	13	34	3	0	0	3	31	30	33	34
Control, inoculated but not treated	6	5	7	6	49	32	16	32	10	39	15	21	82	37	21	47	6	23	4	11	52	41	15	36	25	18	12	18	75	38	23	45	6	11	21	18	32	36	47	45

The removal of smut balls in this experiment had less effect than would have been the case had the seed been handled in greater bulk and sown by machinery. In the latter case the smut balls would have been removed with less thoroughness and there would have been some infection after treatment through the breaking of the remaining smut balls in the drill.

SUMMARY.

The Nephi substation is located in the Juab Valley in the eastern part of Juab County, in central Utah. The altitude of the substation is approximately 6,000 feet.

The average annual rainfall in Juab Valley during 1898 to 1912, inclusive, was 13.61 inches. The winter and spring precipitation is the heaviest of the year. The summer rains have been very small and consequently of little value to the growing crops.

The average evaporation during the six summer months, April to September, inclusive, for the years 1908 to 1912, inclusive, was 45.57 inches. The average daily evaporation for the same period was 0.25 inch.

The average wind velocity per hour during the months of April to October, inclusive, for the years 1909 to 1912, inclusive, was 4.3 miles.

The average length of the frost-free period for the years since 1907 has been 102 days. The latest spring frost occurred on June 22, 1908; the earliest fall frost occurred on August 30, 1908, leaving a frost-free period of 69 days. The maximum frost-free period was in 1910, from May 16 to October 5, a total of 142 days.

The soil at Nephi ranges from a deep clay to a sandy loam, and where it is now found in the virgin condition it is covered with a heavy growth of sagebrush.

The varietal tests on plats have included 105 cereal varieties and strains. There were 68 varieties and strains of winter wheat, 1 of winter oats, 3 of winter barley, 2 of winter emmer, 10 of spring wheat, 7 of spring oats, and 14 of spring barley.

The winter varieties of all cereals have given better results than have the spring varieties.

Of the winter wheat varieties, the hard red group has given the best yields. The soft white group, commonly grown in the Intermountain States, is comparatively low in yield.

The Turkey variety (C. I. No. 2998), the leading hard winter wheat at the substation for several years, is the most satisfactory of the winter wheats. It has been used as a check variety for a number of seasons. Only one variety, Crimean (C. I. No. 1437), ranks higher in actual yield, but its rank is based on the yield of a single plat each year, while the rank of the Turkey is based on an average of several plats.

There seems to have been no definite correlation between stand and yield.

The average date of heading and also the average date of ripening were about the same for all varieties.

The average height of the winter wheats at Nephi during 1908 to 1912, inclusive, was 27 inches.

Approximately 1 pound of grain was produced with every pound of straw.

The average bushel weight for all varieties of winter wheat for the 5-year period was 61.4 pounds, or 1.4 pounds above the standard weight.

The average acre yield of spring wheats since 1908 is only 7.5 bushels for durum varieties and 8.9 bushels for common varieties, which is unprofitable in comparison with the acre yield of 17 to 23 bushels from winter wheats.

Boswell Winter oats have yielded very well in some seasons. In other seasons the yield has been low, thus reducing the average acre yield to 17.2 bushels for 1909 to 1912. However, the variety gives great promise as a winter oat for the intermountain region.

The Black American, Giant Yellow, and Swedish Select varieties of spring oats have acre yields of 15.2, 14.2, and 13.6 bushels, respectively, in 1909 to 1912, inclusive.

Two winter varieties of barley have given promising results. Of these two, Utah Winter (C. I. No. 592) has yielded an average of 19.6 bushels per acre, as against 15.8 bushels for Tennessee Winter (C. I. No. 257).

Three spring varieties were practically failures and were discarded in 1910.

Black Winter emmer has shown itself adapted to conditions at Nephi, and probably will prove a valuable crop on the dry farms of the Mountain States. There was no apparent difference during 1912 between Buffum's Improved Black Winter emmer (C. I. No. 3331) and the ordinary Black Winter emmer (C. I. No. 2337).

The nursery experiments comprised five main groups, namely, head rows, increase rows, minor cereals, tests of the value of different sizes of seed of two spring and two winter varieties of wheat, and tests of different treatments of seed wheat.

The following data obtained from the head rows are directly related to the results of the plat experiments:

(1) The average winter survival of the cereals was about 65 per cent.

(2) The tillering of the winter cereals varied with the thickness of the stand.

(3) The average number of culms per plant in winter cereals seldom exceeded 25, though favored plants would sometimes have a greater number.

(4) The average yields of the head rows gave the winter cereal varieties about the same rank as did the plat experiments.

(5) The spring cereal varieties yielded less than the winter varieties, even though a better stand was obtained.

In the increase rows a decided improvement in the yielding power of the cereal varieties was evident, probably due to the use of pure strains.

Tests with minor cereals have been limited. Some work has been done with grain sorghums, broom corn, millets, and prosos, but the results obtained have given little promise that these crops are adapted to the dry lands of the intermountain region.

In the test of size of seed with both spring and winter varieties, the large seed was best in number of heads produced per plant and in yield per row. No great difference was observed among the different sizes of seed, in the percentage of survival, plants maturing, or length of heads produced.

In the test of different seed treatments for smut, the following points were observed:

(1) The effect of the time of seeding on bunt depended largely on the season.

(2) The best copper-sulphate treatment was 1 pound of copper sulphate to 10 gallons of water, the seed soaked 10 minutes and dried.

(3) The best formalin treatment was 2.5 parts of formalin to 1,000 parts of water, the seed soaked 10 minutes and kept moist 2 hours.

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